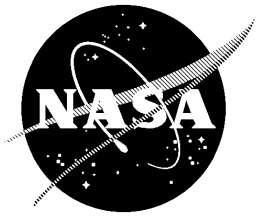
451-OCD-NCCDS/1998

NETWORKS AND MISSION SERVICES PROJECT

Network Control Center Data System (NCCDS) Operations Concept, 1998

June 1999



National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Network Control Center Data System (NCCDS) Operations Concept, 1998

June 1999

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This content of this document supersedes the content *Service Planning Segment Replacement (SPSR) Operations Concept*, 530-OCD-SPSR, and is accurate as of June 1999. However, this document has not been, and will not be, subject to a formal review and approval process.

Goddard Space Flight Center
Greenbelt, Maryland

Preface

The *Network Control Center Data System (NCCDS) Operations Concept, 1998*, 451-OCD-NCCDS/1998, supersedes and updates the *Service Planning Segment Replacement (SPSR) Operations Concept*, 530-OCD-SPSR, issued in February 1995. This operations concept document provides the concepts needed to define functions and operations applicable to the version of the NCCDS that will be fully operational in June 1999 (i.e., the version known as NCCDS 1998). The document represents a consensus of program managers, customers, operators, and developers, with regard to the highest-level definition of the system.

This operations concept serves in combination with the *Network Control Center Data System (NCCDS) System Requirements, 1998*, 451-SRD-NCCDS/1998, as the high-level definition of NCCDS 1998. NCCDS 1998 requirements, specifications, designs and test plans are traceable to these documents.

Information presented herein was prepared for the Network Control Center Project, Code 451.5, Goddard Space Flight Center. There will be no updates to this document.

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Abstract

The *Network Control Center Data System (NCCDS) Operations Concept, 1998*, 451-OCD-NCCDS/1998, provides the concepts needed to define functions and operations applicable to the version of the NCCDS that will be fully operational in June 1999 (i.e., the version known as NCCDS 1998). The document represents the highest-level definition of the NCCDS 1998.

Keywords: Network Control Center, Scheduling, Space Network, TDRS, TDRSS.

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Section 1. Introduction

1.1 Context

The National Aeronautics and Space Administration's (NASA's) Spaceflight Tracking and Data Network (STDN) is a complex communications network encompassing the Space Network (SN), the Ground Network (GN), and all support facilities necessary to provide tracking, telemetry, and command (TT&C) support to its customers. The STDN uses the geosynchronous Tracking and Data Relay Satellites (TDRSs), the ground terminals at the White Sands Complex (WSC), and the GN for supporting orbiting spacecraft and other missions (e.g., scientific research aircraft and balloons).

The Network Control Center (NCC) is the STDN element responsible for overall real-time coordination of network resources to satisfy the support requirements of all network customers. From a customer's perspective, the NCC is the operational interface for obtaining mission support. From a network element's perspective, the NCC is responsible for providing work schedules and coordinating problem resolution.

The Network Control Center Data System (NCCDS) schedules the SN resources. The NCCDS receives and validates customer service requests, generates and maintains the schedule, and disseminates the schedule to the appropriate SN elements and customers. The NCCDS receives acquisition data from the Flight Dynamics Facility (FDF) and SN customers, stores the data, and disseminates acquisition data to the WSC. The NCCDS handles real-time support functions including service control and service assurance, performs service accounting functions, and identifies potential radio frequency interference (RFI) and mutual interference (MI).

1.2 Purpose of Document

The *Network Control Center Data System (NCCDS) Operations Concept, 1998*, 451-OCD-NCCDS/1998 provides the concepts needed to define functions and operations applicable to the version of the NCCDS that will be fully operational in June 1999 (i.e., the version known as NCCDS 1998). The document represents a consensus of program managers, customers, operators, and developers, with regard to the highest-level definition of the system.

This operations concept serves in combination with the *Network Control Center Data System (NCCDS) System Requirements, 1998*, 451-SRD-NCCDS/1998, as the high-level definition of NCCDS 1998. NCCDS 1998 requirements, specifications, designs and test plans are traceable to 451-SRD-NCCDS/1998 which is based on the concepts presented by 451-OCD-NCCDS/1998.

Although the *Network Control Center Data System (NCCDS) Operations Concept, 1998*, 451-OCD-NCCDS/1998 has been published at the end of the development of NCCDS 1998 and is generally consistent with the as-built NCCDS 1998, it is not intended to simply be an as-built description document. In some cases, concepts are presented herein that may not have been fully implemented.

1.3 Applicable Documents

The following documents are applicable to the NCCDS operations concept. In general, revision numbers are not indicated and the most recently approved version of each document should be used.

a. *Interface Control Document Between the Network Control Center Data System and the Mission Operations Centers*, 451-ICD-NCCDS/MOC

b. *Network Control Center 98 Project Management Plan for the Network Control Center Data System*, 530-PMP-NCCDS/1998

c. *Interface Control Document Between the Network Control Center Data System and the NASA Integrated Services Network (NISN)/NASA Communications (Nascom) Event Scheduling Terminal (NEST)*, 451-ICD-NCCDS/NEST

d. *Interface Control Document Between the Network Control Center Data System and the Sensor Data Processing Facility*, 451-ICD-NCCDS/SDPF

e. *Interface Control Document Between the Network Control Center (NCC)/Flight Dynamics Facility (FDF) and the White Sands Complex (WSC)*, 530-ICD-NCC-FDF/WSC

f. *IRIG Standard Parallel Binary Time Code Formats*, IRIG STD 128-77

g. *Mission Operations and Data Systems Directorate Systems Management Policy*, 500-SMP

h. *Mission Requirements and Data System Support Forecast*, 450-803

i. *Space Network (SN) Security Classification Guide (SCG)*

j. *NASA Automated Information Security Handbook*, NHB 2410.9A

k. *NASA GSFC Security Manual*, GHB 1600.1A

l. *Security Plan for the Network Control Center, NCC 98*, 451-SP-NCC/1998

m. *NASA Communications (Nascom) Space Network Ground Segment Support Data Book*, 542-016

n. *Nascom Interface Standard for Digital Data Transmission*, 542-003

o. *Network Control Center Data System (NCCDS) System Requirements, 1998*, 451-SRD-NCCDS/1998

p. *Space Network Flexible Scheduling Enhancements*, TR93102

q. *Tracking and Data Relay Satellite System Functional Description*, STDN No. 117

1.4 Document Content

The remaining sections of this document are arranged as follows:

- Section 2 discusses programmatic considerations, including project objectives and system constraints.
- Section 3 examines the system environment in which the NCCDS will operate, including interfaces.
- Section 4 presents an overview and a description of the functional capabilities provided by NCCDS 1998.
- Section 5 provides scenarios that describe how each of the functional capabilities are used.

Section 2. Programmatic Considerations

2.1 Goals and Objectives

The initial capability of NCCDS 1998 became operational in February 1999, and NCCDS 1998 become fully operational in June 1999. Relative to previous versions of the NCCDS, NCCDS 1998 achieved three primary objectives:

a. Obsolescent hardware and associated vendor-supplied software with high recurring costs were replaced with a client server system using open systems standards (i.e., a network of computers that supports remote processing services and interactive information sharing across vendor and/or equipment boundaries).

b. Although some external entities still interface with the NCCDS using the custom NASA Communications (Nascom) 4800 bit block protocols, NCCDS 1998 has the capability to interface with customers using the standard Transmission Control Protocol (TCP)/ Internet Protocol (IP) suite of protocols and could transition to use of TCP/IP on any external interface.

c. A flexible scheduling capability is provided to the SN customers.

Although the first two objectives are of critical importance, they do not involve significant conceptual changes in SN operations. Therefore, this document focuses on the new flexible scheduling capability.

2.2 Governing Policies

The following policies apply either to the NCCDS 1998 development process, to NCCDS 1998 operations, or to specific capabilities provided by NCCDS 1998.

a. Development of NCCDS 1998 began when the Network Control Center Project was part of the Mission Operations and Data Systems Directorate (MO&DSD). Although the MO&DSD has ceased to exist, NCCDS 1998 development was initiated under and has generally continued to adhere to the management policies described in the *Mission Operations and Data Systems Directorate Systems Management Policy*, 500-SMP, March 1993.

b. NCCDS software development and operations must adhere to NASA and Goddard Space Flight Center (GSFC) Management Instructions, policies, requirements, and guidance. Deviations and waivers require NASA management approvals.

c. NCCDS software development and operations must adhere to security requirements established by the *Security Plan for the Network Control Center, NCC 98*, 451-SP-NCC/1998.

d. The NCCDS must provide TDRSS scheduling and service accounting capabilities in accord with policies applicable to non-NASA users of the TDRSS as defined by:

   1. NMI 8410.2B, *Subject: TDRSS; Use and Reimbursement Policy for Non-NASA US Government Users*, December 1991

   2. NMI 8410.3B, *Subject: Tracking and Data Relay Satellite System (TDRSS); Use and Reimbursement Policy for Non-US Government Users*, December 1991

2.3 System Constraints

Three significant constraints have been imposed on the development and operation of NCCDS 1998:

a. The NCCDS 1998 is a mixture of new and legacy elements. The new elements are designed to operate together with the legacy elements, and to require a minimum of change to these legacy elements. The design of NCCDS 1998, as a whole, must facilitate the eventual replacement of the legacy elements.

b. The NCCDS 1998 must be implemented and operated within the existing NCC facility, and require no expansion or upgrade to the infrastructure of that facility.

c. In order to achieve the goals of providing an external interface based on standard protocols and of providing a flexible scheduling capability to the SN customers, substantial message format changes were necessary. However, the NCCDS 1998 is also required to maintain full backward compatibility with legacy customers. In effect, the NCCDS 1998 must be bilingual.

Section 3. System Environment

3.1 NCCDS System Overview

The NCC is a complex, integrated entity encompassing several facilities, data systems, operations personnel, and communication interfaces. The NASA Integrated Services Network (NISN) provides the communication links connecting the NCC with STDN customers, the Sensor Data Processing Facility (SDPF), the FDF, the WSC, GN elements, and with the NISN Event Scheduling Terminal (NEST).

The central element of the NCC is the NCCDS whose role is to schedule, control, and monitor SN resources.

3.1.1 Scheduling, Acquisition Data Handling, and Data Storage

The NCCDS receives and validates customer service requests, generates and maintains the schedule, and disseminates the schedule to the appropriate SN elements and customers. The NCCDS also receives acquisition data, and stores and disseminates acquisition data that the WSC uses for TDRS antenna pointing and for Doppler shift prediction and compensation. The NCCDS also maintains data relevant to TDRSS services, customer spacecraft characteristics, SN customer characteristics, WSC resources, and the NCC operators.

3.1.2 Control and Monitoring

The NCCDS supports functions that are critical for real-time support of ongoing services, such as service reconfiguration, and the receipt, validation, display, and dissemination of TDRSS performance data. These functions rely on the database for the active schedule and for user-specific control and configuration information.

3.1.3 Service Accounting

The NCCDS provides after-the-fact accounting reports on the use of the NCC and network resources. This capability relies on information that can be extracted from the NCCDS database and from messages exchanged between the NCC and external elements.

3.1.4 Identifying RFI and MI

The NCCDS identifies potential MI between customer spacecraft and highlights possible RFI from known ground-based RF sources. This capability relies on information that can be extracted from the NCCDS database.

3.1.5 Other

In addition to the NCCDS, the NCC includes the following hardware and software components:

a. The Multimission Display Processing System (MMDPS) monitors and displays selected operational data parameters via closed-circuit television (CCTV).

b. CCTV provides for distribution of video displays including shuttle TV throughout the NCC.

c. Cryptographic devices encode and decode sensitive data on transmission and receipt.

d. The Test, and Training (T&T) facility provides a set of capabilities that effectively duplicate the operational NCCDS without its redundant hardware. The primary purpose of the T&T is to facilitate the testing of new software, systems, and procedures. An important feature of the T&T is the ability to establish communication links with external entities allowing test personnel to conduct interface tests without affecting operations. It is also used to train NCC personnel.

e. The NCC Test System (NTS) is a key element of the T&T used to simulate external NCC interfaces.

f. The GSFC Timing System provides Coordinated Universal Time (UTC) that is used as a synchronized timing signal for NCC systems.

g. The NCC Timing Display System (NTDS) provides a variety of timing displays, such as countdown clocks, that can be synchronized with remote locations.

h. The Electrospace Systems, Inc. telephone system provides the primary capability for NCC voice communications.

i. The Voice Distribution System (VDS) provides the backup capability for NCC voice communications.

j. The red/black voice system provides communications between all elements.

k. The Ground Network Scheduling System (GNSS) schedules GN services independent of TDRSS.

l. The Mission Operations Support Area (MOSA) provides the capability for monitoring the performance of GN services, as well as detecting and resolving their faults.

m. The Cabletron switches provide automated capability for configuring LAN connections within the NCC.

3.2 Operational Environment

The NCCDS exchanges message traffic with external entities to support its operational activities, which include scheduling SN resource usage, processing acquisition data, SN service control, and service assurance. These interfaces are discussed in Subsection 3.5.

The operational emphasis of the NCCDS is on activities that require highly effective processing of schedules, acquisition data, and real-time service control messages. The NCCDS functions require varying degrees of NCC operator control and oversight:

- Real-time functions (e.g., TDRSS service reconfigurations in response to customer requests) generally operate automatically with no direct NCC operator control.
- Functions that operate in the time range from a few minutes to a few days prior to real-time (e.g., active schedule updates and acquisition data dissemination) are designed so that they could operate automatically; however, the NCC operators often take control of these functions.
- Functions that operate either well in advance of real-time (e.g., forecast schedule generation and database maintenance) or after-the-fact (i.e., service accounting) are designed to require operator control.

The NCCDS operates 24 hours per day. Automated activities (such as processing of active period schedule requests) are handled at any time. Operator-controlled activities (such as generating the weekly SN schedule or resolving conflicts) are normally carried out during the daytime shift.

Operator interfaces enable NCC operators to create forecast and active period schedules for SN services, handle acquisition data, and supervise SN service control and service assurance functions.

The NCCDS is designed to eliminate system constraints on network managers resulting from fixed allocations of responsibilities to operator positions. Operator access to specific NCCDS capabilities is directly controlled via a set of assigned privileges. Specific capabilities may be assigned and deassigned to individual operators as operational conditions warrant. The privilege to assign operational capabilities is limited and granted only to a few highly privileged operators.

Operations in the NCC are conducted in compliance with security requirements. Operational security issues are discussed in Subsection 3.4.

Hardware maintenance is performed using logistical resources and personnel assigned to the GSFC Building 13 complex. Software maintenance is provided using the capabilities of the T&T facility located at the NCC. The Software Development Environment (SDE), located in Building 13, is the principal development environment for the NCCDS. All NCCDS development and maintenance activities within the SDE, T&T, or other facilities are coordinated with each other.

3.3 Customer Environment

SN customers are those entities that request SN services to support activities such as the operation of spacecraft in low Earth orbit. These customers operate from within facilities generally referred to as Mission Operations Centers (MOCs). However, some specific facilities may use other terminology such as Payload Operations Control Center (POCC). Customer scheduling systems [e.g., User Planning System (UPS)] interact with the NCCDS to schedule periods of SN support for their spacecraft. The NCCDS is backward-compatible with customer interface systems that were compliant with the original version of 530-ICD-NCCDS/MOC

published in April 1996. However, such customers who continue to use such systems cannot take advantage of many of the new features of NCCDS 1998.

Customers establish their mission requirements during the pre-mission planning period and provide several types of information to the NCC. Service specification codes define the specific parameters needed for each service. Prototype events are predefined templates for events with multiple services. In addition, customers may submit specific schedule requests for other near-term needs beyond those defined during the pre-mission planning period. Based on all supplied information, the customer's SN schedule is generated weekly by the NCC using the NCCDS.

Electronic message exchanges between the customer and the NCCDS may be supplemented by voice coordination between NCC and MOC scheduling operators using NISN-provided voice circuits or commercial telephone lines.

The NCCDS must be flexible enough to accommodate evolving customer requirements. Toward the end of the 1990's, a number of new customers are planning to become operational. The majority of new customers will require higher data rates, increased coverage, and support of targets of opportunity. Such new requirements on the NCCDS allow for improvements in the ability to resolve contention for limited data transport resources, more effective scheduling of TDRSS resources, and quicker response to unforeseen circumstances.

SN customers are responsible for providing service requests that meet their mission needs and constraints. Requests must be consistent with NCC-specified operational procedures and timelines, SN capabilities, message formats specified in interface control documents (ICDs), and approved service requirements. Based on the totality of requests, the NCC is responsible for generating schedules for use of SN resources. Schedules must be generated and provided to customers in a timely fashion to enable them to adequately plan mission operations for use of SN services.

3.4 Security Environment

The NCC, located in Building 13 of GSFC, operates under secure conditions. In order to support all applicable computer, communications, personnel, and physical security requirements, the following actions are necessary:

- Delivered software undergoes stringent acceptance testing, and an AIS certification process prior to operational use.
- While the NCCDS is in operational use at the NCC, the operations and maintenance contractor adheres to approved local operating procedures for the protection of sensitive materials, data, and information in accord with applicable security documents listed in paragraph 1.3.
- Personnel security clearance [e.g., Office of Personnel Management (OPM) National Agency checks for access to unclassified automated information systems] is required for support on an operational system (AIS sensitivity/criticality level 3) within the NCC.

3.5 NCCDS Interfaces

The NCCDS maintains electronic interfaces with a number of external entities as illustrated in Figure 3–1. Each segment of the NCCDS has unique interfaces with external entities. Depending on the particular NCCDS segment, communications may require protocol conversions within the NCCDS and/or at the external entity. For each of these entities, the following paragraphs describe the principal features of the interface and identify the applicable ICD which provides a detailed description of the interface. The security measures applicable to each interface are identified by that ICD and by the *Network Control Center Data System (NCCDS) System Requirements, 1998*, 451-SRD-NCCDS/1998.

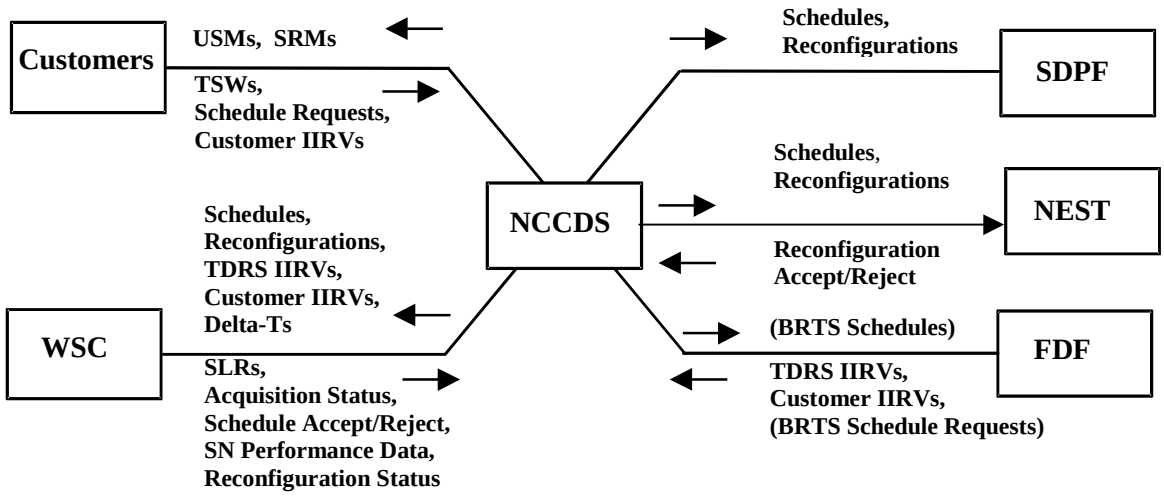


Figure 3–1. NCCDS Interfaces with External Entities

3.5.1 White Sands Complex

The WSC comprises two functionally equivalent ground terminals: the White Sands Ground Terminal (WSGT) and the Second TDRSS Ground Terminal (STGT). Each ground terminal is responsible for controlling up to three operational TDRSs and for providing customer services for telemetry, tracking, and commanding. As shown in Figure 3–1, the NCCDS supplies each ground terminal with schedules (to properly configure the ground station for supporting the customer's spacecraft), reconfigurations (to change SN service configuration in real time), and acquisition data. In response, the ground terminals return schedule accept/reject messages, reconfiguration status messages, and acquisition data status messages to the NCCDS. The ground terminals also generate performance data during service support. Each ground terminal independently provides NCCDS with service level reports (SLRs) that identify status and availability of its schedulable TDRSS resources (i.e., both ground terminal resources and TDRS resources allocated to the ground terminal). Free-text messages are available to exchange other operational information and status.

The applicable ICD is the *Interface Control Document Between the Network Control Center (NCC)/Flight Dynamics Facility (FDF) and the White Sands Complex (WSC)*, 530-ICD-NCC-FDF/WSC.

NOTE

The Guam Remote Ground Terminal (GRGT) is physically separate from the WSC. However from the perspective of the NCCDS, the GRGT functions as part of the WSGT and is scheduled as part of the WSGT.

3.5.2 Sensor Data Processing Facility

The NCCDS generates schedules and reconfigurations for the SDPF for each data flow requiring telemetry processing at an SDPF data capture and processing facility. No messages are received from the SDPF in response.

The applicable ICD is the *Interface Control Document Between the Network Control Center Data System and the Sensor Data Processing Facility*, 451-ICD-NCCDS/SDPF.

3.5.3 NEST

The NCCDS generates schedules and reconfigurations for the NEST for nearly all scheduled events. The NEST provides responses for service reconfigurations, but does not provide responses for schedules.

The applicable ICD is the *Interface Control Document Between the Network Control Center Data System and the NASA Integrated Services Network (NISN)/NASA Communications (Nascom) Event Scheduling Terminal (NEST)*, 451-ICD-NCCDS/NEST.

3.5.4 Flight Dynamics Facility

The NCCDS receives acquisition data (both customer vectors for many SN customers and TDRS vectors) from FDF for subsequent transmission to the ground terminals. FDF also operates the Bilateration Ranging Transponder System (BRTS) for TDRS orbital determination.

3.5.5 Mission Operations Centers

MOCs are responsible for overall control of a customer's spacecraft. These centers are used by customers to interact with the NCCDS to schedule SN support of spacecraft. Schedule requests are submitted by the MOC (using a UPS or other means). After processing, customer schedules and associated status messages are transmitted to the MOC. The MOC is also responsible for providing TSWs to the NCCDS. Some MOCs provide acquisition data directly to the NCCDS in lieu of using the FDF.

The applicable ICD is the *Interface Control Document Between the Network Control Center Data System and the Mission Operations Centers*, 451-ICD-NCCDS/MOC. This ICD also applies to the interface between the NCCDS and the FDF as described in 3.5.4.

3.6 System Characteristics

3.6.1 High-Level Reference Architecture

The NCCDS comprises a distributed environment utilizing client/server technology consisting of server(s) and client workstations (e.g., X Terminals) connected via a LAN. These workstations are used for operator interface and are compatible with the NCC CCTV and video distribution system. A limited portion of legacy NCCDS software has been retained in NCCDS and continues to be hosted on a minicomputer.

With the exception of this legacy code, the software for the NCCDS is vendor-independent and uses open systems industry standards such as a POSIX-compliant operating system. In addition to being supported by multiple vendors, such an operating system commonly provides native support for Transmission Control Protocol/Internet Protocol (TCP/IP). The NCCDS software is written in widely accepted programming languages that directly support improved reuse and maintenance practices using object-oriented programming. Each operator has access to basic desktop accessories such as word processors, spreadsheets, e-mail, and calculators.

The NCCDS uses a modern industry standard graphical user interface (GUI) that provides the operators with a consistent, intuitive, user-friendly interface with the NCCDS functions. A standard interface simplifies operator and developer training as well as improves both operator and developer efficiency. NCCDS operator interfaces are implemented using a commercial GUI builder to reduce implementation, maintenance, and enhancement costs.

The database management system (DBMS) used for the NCCDS system uses standardized, transportable database technology. The DBMS can be integrated into a multivendor environment. The DBMS minimizes, if not eliminates, the need for system restarts due to database maintenance. Access to the DBMS is not limited to specific terminals and includes a GUI for database functions. Access to the DBMS is limited by the privileges assigned to the operator.

3.6.2 System Performance

The performance requirements for the NCCDS functions are described in *Network Control Center Data System (NCCDS) System Requirements*, 1998, 451-SRD-NCCDS/1998.

The NCCDS has sufficient capacity and capability for expansion to provide enhanced scheduling to support the increased number of resources, customers, and demands projected for the late 1990's and beyond. The number of requests for SN services during the late 1990's is expected to approach 3000 requests per week.

Reliability, maintainability, and availability requirements are also satisfied. For critical support functions, the mean time between failures (MTBF) is required to be more than 2500 hours; the mean time to repair (MTTR) is required to be less than 30 minutes. Operational availability—the proportion of time for which the system is available to perform service on demand—is required to be 0.9998.

Section 4. System Concepts

4.1 Introduction

This section provides an overview of the NCCDS system operations and describes in detail the concepts and functions supported by the NCCDS. Several operations scenarios are described in Section 5.

NCCDS system operations and concepts fall into the following four functional areas:

a. Data Administration

b. Schedule Generation and Maintenance

c. Acquisition Data Handling

d. Real-time Control and Performance Monitoring

4.2 Operations Overview

4.2.1 Data Administration Operations

Data administration functions relate both to the SN and to individual customers. SN data describe the resources scheduled by the NCCDS. Changes to this data may occur as a result of planned network modifications or unplanned equipment failures. Data are entered in the database by the NCC operator for use by the scheduling system. For unplanned changes, the scheduling system supports identification of impacted events and assists in rescheduling to minimize the impact on customer support.

Customer data maintenance is generally initiated during the planning phase for a new mission requiring TDRSS support and continues throughout the mission. These data specify the characteristics of the desired communications support and parameters used in the scheduling process.

4.2.2 Schedule Generation and Maintenance Operations

Figure 4–1 shows the activities associated with scheduling customer support as a function of time. Time intervals shown here are 1-week periods, but may be of any length; however, the total period available for scheduling activities is limited to 28 days. Customers may submit requests for any time in the 28-day window. All requests for the forecast scheduling period should be received and stored before the forecast schedule is generated. Coordination between customers and the NCC operators is necessary to carry out the operations described below.

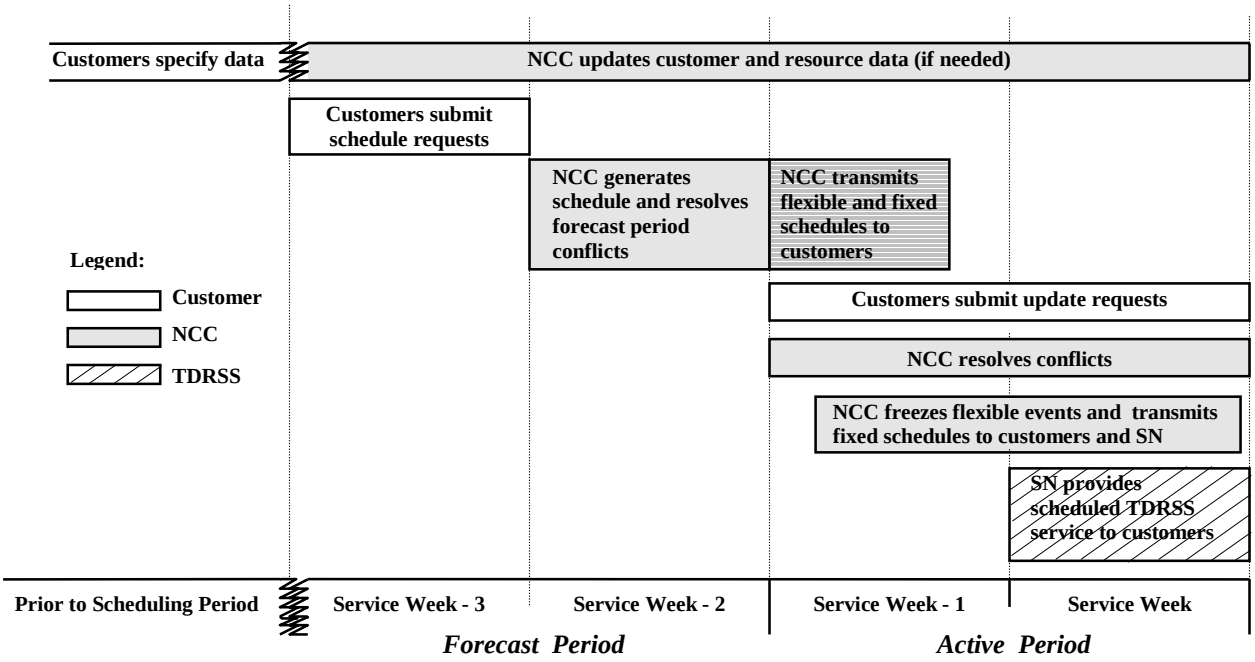


Figure 4–1. Scheduling activities are sequential and time-sensitive

4.2.2.1 Forecast Scheduling Period

Forecast scheduling begins 3 weeks before the beginning of the service week (i.e., the week in which the requested services are to be scheduled). Each customer submits specific schedule requests for support that is desired throughout the service week. Each request may specify flexibility regarding the time and resources to be used and alternate requests to be considered if the original request cannot be scheduled.

The scheduling operator ensures that all requests and TDRS scheduling windows (TSWs) are received prior to generating a schedule. If necessary, the scheduling operator contacts the customer to initiate the transmission of requests and TSWs. For customers who specify flexibility in their requests, the operator may also coordinate transmission of TSWs. These windows, derived from customer orbit information, antenna pointing constraints, and other constraints related to science or spacecraft operations, indicate the times and TDRSs on which events may be scheduled. Use of TSWs allows customers to specify greater flexibility in their schedule requests which results in increased scheduling success.

4.2.2.2 Schedule Generation

The scheduling operator reviews the forecast request queue to verify that all the expected requests for the forecast period have been received. For those customers using TSWs, the operator verifies that the TSWs for the forecast period have also been received.

Based on the characteristics of the type of support requested for the service week (e.g., space shuttle in orbit, special targets of opportunity), the operator may control the inputs to schedule

generation by selecting different subsets of requests for scheduling, editing requests, or adjusting priorities. The operator initiates the schedule generation process for each set in turn and saves each resulting alternative forecast schedule, or may initiate the schedule generation process for all queued requests and generate a single forecast schedule. These schedules contain events for multiple customers and may retain the flexibility included in the original requests. Start times, service durations, and resource allocations may retain flexibility.

Using displays that allow for comparisons of the alternate schedules, the operator selects the most effective forecast schedule for further enhancement. Utilizing the operator-assisted conflict resolution tools and knowledge of the customer's support requirements, the operator resolves any initially unscheduled requests. This resolution is accomplished by deleting, modifying, or moving scheduled events, and/or modifying the unscheduled requests, all within the guidelines for levels of customer support.

When satisfied with the schedule, the operator activates the final forecast schedule and sends User Schedule Messages (USMs) to the customers.

4.2.2.3 Active Scheduling Period

Several activities may take place concurrently during the active period. After the customers receive their schedule messages, they may alter their schedule by sending messages to add, delete, or replace events. The active scheduling period is partitioned into two phases: the automatic schedule update phase and the batch scheduling phase. Requests that fall in the automatic schedule update phase (e.g., within three days) are processed immediately in first-in-first-out order without regard to priority and without operator intervention. Requests that do not do not apply to the automatic schedule update phase are held for batch processing under operator control. If a request cannot be scheduled, the operator may attempt to manually schedule it by using the operator-assisted conflict-resolution capabilities as in the schedule generation process. Requests that cannot be scheduled may be wait-listed by the customer.

Events that still retain flexibility must become "frozen" (all time and resources specified) before they can be supported by the network. An event may be frozen at a default freeze interval as specified in the customer database, at a freeze interval as specified in the original request, or at schedule transmission to SN elements. When an event is frozen, a fixed USM is sent to the customer.

Changes to the TSWs may be sent if the spacecraft orbit changes after the forecast schedule is generated. These updated TSWs are applied to scheduled events under operator control. Depending on the degree of impact of the TSW updates, the operator may take appropriate action on some of the affected scheduled events.

At operationally determined times (usually once to several times a day), the composite schedule is transmitted to the SN elements—the ground terminals (WSGT and STGT), the NEST and SDPF—involved in supporting the event. The operator defines transmission rules that perform the schedule transmissions automatically, so that manual operations are not necessary. The operator has the capability to terminate any transmission in progress and to initiate manual

transmissions. The schedule that was sent to the ground terminals is available for real-time support functions.

4.2.3 Acquisition Data Handling Operations

The acquisition data handling capability of the NCCDS provides for the receipt, validation, storage, and transmission of Improved Interrange Vectors (IIRVs). The NCCDS receives TDRS IIRVs from the FDF and provides them to the ground stations. The NCCDS receives customer IIRVs from the FDF or from customers not supported by the FDF and provides them to the ground stations for determination of TDRS antenna pointing and Doppler compensation for the forward- and return-link carrier frequencies. The IIRVs stored in the NCCDS normally span several days, and are updated each day as new orbit predictions become available. The operator may also create, store, and delete IIRVs.

The operator may generate and transmit a delta-T message to the ground terminals to indicate that the epoch time in the specified IIRVs should be adjusted by a specified amount. This message is normally used to adjust IIRVs for launch delays within the launch window.

The NCC operator may review vectors at various levels of detail from high-level summaries to individual vectors, and may review the history of the IIRV and delta-T messages transmitted to any site.

The NCCDS periodically, as specified by parameters entered by the operator, deletes old IIRVs, except those for permanent Earth stations and test support identification codes (SICs). The NCCDS periodically audits the stored vectors for conformance to operator-specified criteria, such as minimum timespan. The operator is alerted to any discrepancy.

Normally, the operator enters and initiates a set of IIRV rules to control transmission of the vectors to the ground terminals. These rules are normally set to transmit a designated set of vectors at specified periods during the day. The operator may select a final review option, in which case the transmission will not occur until operator approval. The operator is alerted when a transmission starts, and may initiate a status display of the ongoing transmission. The operator may terminate any transmission and manually transmit any set of vectors.

4.2.4 Real-time Control and Performance Monitoring

The NCCDS provides the capability for customers to change certain characteristics of the SN service in progress for their spacecraft. Examples are reconfiguration of data rates, changes in mode of support (e.g., coherent or noncoherent), or reacquisition of service. While an SN service is in progress, NCCDS disseminates performance data to customers.

4.3 Concepts Descriptions

This section provides a detailed description of the concepts and functions supported by NCCDS.

4.3.1 Data Administration Concepts

The NCCDS provides a data administrator the capability to create, control, and maintain the data necessary for scheduling SN resources. This data falls into three primary groups:

a. Space Network data. This data defines a logical model of the SN which is used by the NCCDS in the scheduling process.

b. Customer data. For each customer, this data defines that customer to the NCCDS and specifies how the customer will use the SN.

c. NCCDS scheduling control data. This data is entered by the operator to control the NCCDS scheduling process.

NOTE

Paragraph 5.2 of 451-SRD-NCCDS/1998 provides a detailed description of this data.

4.3.2 Schedule Generation and Maintenance Concepts

The NCCDS supports the following schedule generation and maintenance concepts:

a. Use of schedule request flexibility

b. Use of TSWs

c. Generation of schedules with increased effectiveness

d. Improved operability

4.3.2.1 Schedule Request Flexibility Concepts

The schedule request flexibility concepts depend on a variety of parameters. Some of these parameters are maintained in the NCCDS database. In particular, this includes parameters specified in the service specification code (SSC). Other parameters are directly specified in the schedule requests. The request format is a hybrid of fixed and keyword formats with service-level time-oriented flexibility being specified by keyword parameters.

The NCCDS supports the following schedule request flexibilities:

a. Resource flexibility

b. Event start-time flexibility

c. Service start-time flexibility

d. Flexible-service durations

e. Primary and alternate requests

f. Flexibility retention until customer-specified freeze time

g. Customer-assigned priorities within customer's requests

NOTE

Appendix D of 451-ICD-NCCDS/MOC provides guidelines for use of the service-level flexibility parameters.

4.3.2.1.1 Resource Flexibility

The NCCDS supports requests with open TDRS selection, TDRS SA antenna selection, TDRS MA and SMA return link selection, and User Interface Channel (UIFC) selection.

a. A customer specifies TDRS flexibility in a schedule add request by referencing a predefined list of TDRSs specified in the NCCDS database. For example, a customer can specify all TDRSs in the eastern hemisphere or some in the eastern hemisphere and some in the western hemisphere or all in the western hemisphere. The customer must be authorized to use at least one of the TDRSs in the predefined list of TDRSs.

b. A customer specifies SA antenna flexibility when the customer's SSCs are defined.

c. MAR and SMAR links are always implicitly flexible. The customer cannot specify a specific MAR or SMAR link.

d. A customer specifies UIFC flexibility when the customer's SSCs are defined. This capability is particularly useful for customers who have some UIFCs that are valid only for WSGT and others that are only valid for STGT. A single SSC can specify both WSGT-only and STGT-only UIFCs. In such cases, the NCCDS will automatically select the correct UIFC based on the scheduled TDRS and on the TDRS to ground terminal mappings.

During the processing of an individual request, the NCCDS will freely use resource flexibility. All specified resources of the same type are regarded as equivalent. There is no specified or implied preference order.

Resource flexibility increases overall scheduling success and decreases the number of conflicts requiring operator-assisted conflict resolution. It particularly increases the scheduling success of customers who use resource flexibility.

4.3.2.1.2 Event Start-Time Flexibility

The NCCDS supports requests with event start-time tolerances. Event start-time tolerances allow the customer to specify a window within which the event start time may be placed. The NCCDS attempts to schedule the event to start nearest to the requested event start time without conflicting with other events. Event start-time tolerances in conjunction with TDRS flexibility and TDRS scheduling windows allow the customer to specify maximum available flexibility with minimal effort.

Event start-time tolerances increase customer scheduling success and overall scheduling success. They also decrease the number of conflicts requiring operator-assisted conflict resolution.

4.3.2.1.3 Service Start-Time Flexibility

4.3.2.1.3.1 Service Start-Times and Service Coupling

Service start times are specified as relative times rather than as absolute times. For each service, the schedule request must specify service start-time in one of three ways:

a. The service is specified as being coupled to another service. The service's nominal start time is specified as an increment to the referenced service's start time.

b. The service is specified as being bounded by another service. There is no explicit specification of a nominal service start time. The service is allowed to slide anywhere within the referenced service such that its start time is greater than or equal to the start time of the referenced service and its stop time is less than or equal to the stop time of the referenced service. This method combines service coupling, implicit specification of the nominal start time, and implicit specification of service start-time tolerances.

c. The service is coupled to the event start time. The service's nominal start time is specified as an increment to the event start time. This is specified by default when there is no explicit specification of service coupling or service bounding. Within each request, at least one service must have its start time relative to the event start time.

4.3.2.1.3.2 Service Start-Time Tolerances

The NCCDS supports requests with service start-time tolerances. Service start-time tolerances allow the customer to specify a window within which the service start time may be placed. Flexibility is specified by providing a plus and a minus tolerance on the start time of each service relative to a referenced service or relative to the event start time. The NCCDS schedules the request such that the services start at any time within the period allowed by the specified service start-time tolerances. The NCCDS attempts to schedule the services to start nearest to the requested relative start time without conflicting with any other customers.

Figure 4–2 shows that service start-time tolerances, even without service duration flexibility, may result in flexible-requested event durations. Service start-time tolerances eliminate the need for a fixed relationship with the event start time and allow customers to specify flexible relative start times between subsets of services within an event, when appropriate. Figure 4–3 shows an example in which a subset of services are jointly flexible with respect to another service while the services in the subset are fixed with respect to each other. Service start-time tolerances increase overall scheduling success and decrease the number of conflicts requiring operator-assisted conflict resolution. They also increase the scheduling success of customers who take advantage of service start-time tolerances.

4.3.2.1.4 Flexible Service Durations

The NCCDS supports requests with flexible-service durations. Customers submit a request with flexible-service durations by specifying a nominal duration, and a minimum acceptable duration for each service. If conflicts occur when attempting to schedule using the specified nominal duration, the NCCDS schedules the service at the longest possible duration without creating

conflicts. Service duration flexibility is generally applied only after use of resource and start time flexibility has failed to resolve conflicts.

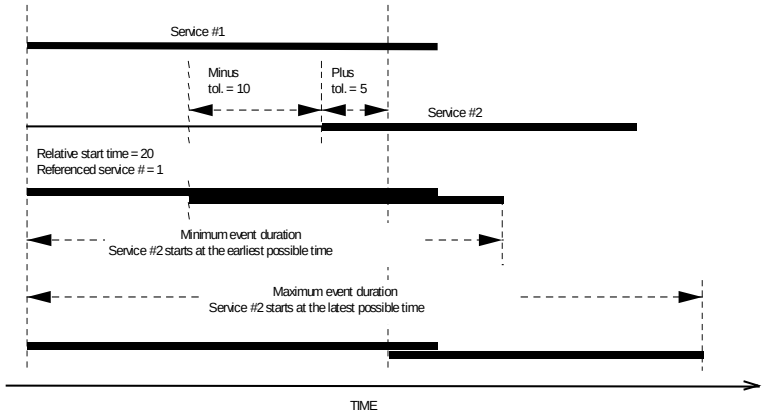


Figure 4–2. Service start-time tolerances mean flexible event durations, even without service duration flexibility

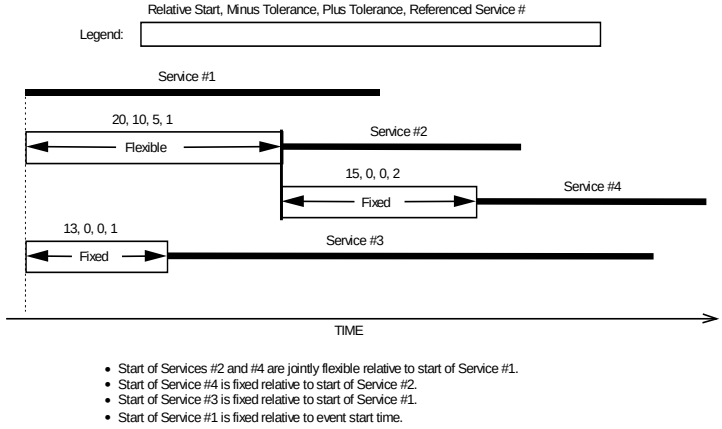


Figure 4–3. Service start-time tolerances eliminate the need for fixed relationships with event start times

4.3.2.1.5 Primary and Alternate Requests

The NCCDS supports primary and alternate requests as described in Figure 4–4. Primary and alternate requests allow customers to specify an alternate request if a primary request cannot be scheduled for any reason. An alternate request allows use of less preferred or fewer resources and/or times when preferred resources and/or times are not available. An alternate request always refers to the request to which it is an alternate. An alternate request may refer to another alternate request, implying preference of the former request over the current one. All alternates, directly or

indirectly by a chain of alternates, refer to a primary request. A primary request never refers to an alternate. The NCCDS attempts to schedule an alternate request only when all of the higher members in the chain of requests cannot be scheduled. The alternate request capability also increases overall scheduling success and decreases the number of conflicts requiring operator-assisted conflict resolution. It also increases the scheduling success of customers who provide alternate request capability.

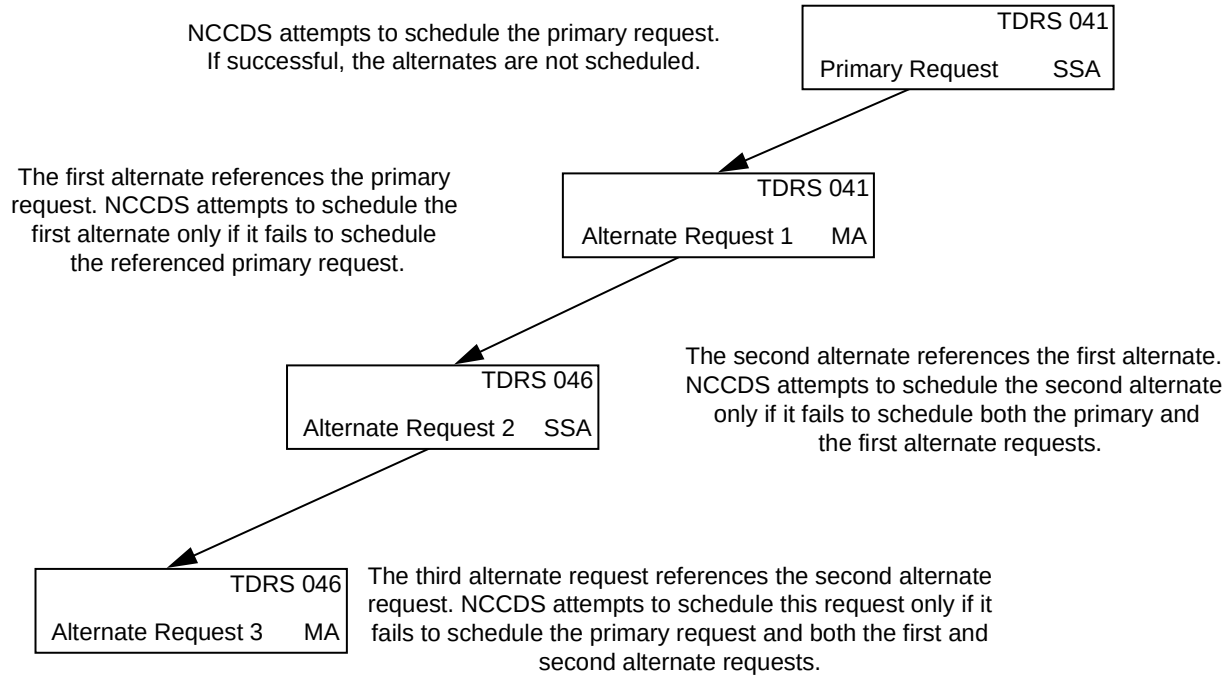


Figure 4–4. Alternate requests allow customers to specify preferences for resources and event times.

In addition, the alternate request capability implicitly provides the capability to request optional services within a request. For example, a customer may submit two requests: a primary request with two required services and an optional service, and an alternate request with only the two required services. The NCCDS attempts to schedule the primary request first; if unsuccessful, the NCCDS attempts to schedule the alternate request.

4.3.2.1.6 Flexibility Retention Until Customer-Specified Freeze Times

When an event is scheduled with one or more service durations reduced below the specified nominal durations, the NCCDS retains the flexibility specified by the original schedule request until the event is frozen. The actual freeze time is determined by a customer-specified time. Most customers need to know the precise start time, service durations, and resources associated with their scheduled requests only a few days before the requested earliest start time and several days after the final forecast schedule is generated. NCCDS uses this customer flexibility to allow the

precise start time, service durations, and resources of the scheduled request to be frozen after the forecast schedule is generated.

When a final forecast schedule is generated, NCCDS initially notifies the customer about the flexible scheduled events using flexible USMs. When the NCCDS subsequently freezes a flexible scheduled event, it sends a fixed USM to the customer. The flexible USM and the fixed USM are very similar. Both include specific information about scheduled resources and times. However, the resources and times specified in the flexible USM are subject to change at NCC's discretion, whereas the resources and times specified in the fixed USM are not subject to change under nominal conditions.

Waiting to freeze scheduled events until the latest possible freeze time allows the NCCDS to use all of the originally specified flexibility to attempt to increase the reduced service durations. However, the NCCDS will never reduce service durations during the freezing process.

NCCDS freezes each flexible scheduled event at the earliest of

a. A default freeze time in the customer parameter database

b. A request-specific freeze time specified in the schedule request

c. The time when the event is selected for transmission to a SN element, or other destination, that cannot accept a flexible schedule

4.3.2.1.7 Customer-Assigned Priorities Within a Customer's Requests

For forecast period scheduling and for active period batch scheduling, the NCCDS uses a three dimensional priority scheme. The first and third dimensions are based on the customer-assigned priority specified within each schedule request. The second dimension is the mission priority assigned by NASA. Five general support levels are defined based on the customer-assigned priorities:

a. Emergency support

b. Critical operations support

c. Critical science support

d. Normal support

e. Supplemental support (i.e., support over and above SN commitment to the customer)

The NCCDS resolves conflicts by first using the general support level (e.g., emergency requests for the lowest priority mission have precedence over non-emergency requests for all missions), and then using the mission priority within each general support level.

The third dimension of the priority scheme divides the normal support level into high normal, routine normal, and low normal support sub-levels. The NCCDS resolves conflicts among normal support requests for a mission by use of these sub-levels.

The NCCDS provides the capability for the operator to temporarily reorder the scheduling priorities in generating a schedule. The NCCDS also provides the capability to monitor and

control the use of customer-assigned priorities by allowing the NCC operator to specify limits on the number of requests allowed for each level of customer-assigned priority.

Customer-assigned priorities increase effectiveness of scheduling of SN resources by

a. Producing customer scheduling successes that are more equitable.

b. Increasing the scheduling success of more important requests.

c. Increasing the effective use of SN resources.

d. Decreasing the need for operator modification of initial schedules.

4.3.2.2 TDRS Scheduling Windows

A TSW is a customer-specified time period applicable to a customer-specified TDRS during which SN services can be scheduled for that customer on that TDRS. Each customer is free to determine the criteria used to determine whether services can be scheduled at a particular time. However, TSWs will generally incorporate all relevant radio frequency (RF) visibility (i.e., Earth occultations, antenna masking, other spacecraft-specific factors) and mission-specific scheduling constraints. The NCCDS uses TSWs to schedule a specific schedule request whenever the customer specifies their use in the schedule request.

For many customers, a single set of TSWs can specify all the schedulable support windows. However, for some customers, TSWs depend on user antenna, service type, and operational preferences. Multiple sets of TSWs allow the customers and the NCC to efficiently handle the individual needs of such customers.

Use of TSWs increases scheduling effectiveness by

a. Allowing customers to decouple the specification of schedule requests and the specification of scheduling windows. In general, this allows schedule requests to use start time flexibility that covers time periods outside of the scheduling windows. In particular, it allows for use of TDRS flexibility.

b. Allowing more effective and efficient operator-assisted conflict resolution.

4.3.2.2.1 Approach for Specification and Use of TSWs

NCCDS provides the capability to receive and use TSWs as follows:

a. The default TSW set identification (TSW-Set-ID) applicable to each SSC is stored in the database as part of the SSC. Additionally, the TSW-Set-ID is a respecifiable parameter in the SSC.

b. The customer or customer-designated facility generates TSWs and electronically transmits them to the NCC for a period up to 28 days into the future. A customer or customer-designated facility generates and transmits multiple sets of TSWs when requests require use of multiple TSW sets.

c. The customer or customer-designated facility transmits TSW updates when necessary.

d. The customer explicitly requests or inhibits TSW checking for all services in a schedule request.

e. The customer requests use of a different TSW-Set-ID for a particular service in a request by respecifying the TSW-Set-ID for that service as the new TSW-Set-ID.

f. NCCDS validates that each service of a request can be scheduled during at least one of the periods of the associated TSW set while ensuring that the time relationships between the services of the request are satisfied.

g. NCCDS schedules each service in a request to occur entirely within one of the periods of the associated TSW set while ensuring that time relationships between the services of the request are satisfied.

4.3.2.2.2 Use of TSWs With Scheduling Preferences

Multiple sets of TSWs allow the customers and the NCC to efficiently handle the needs of customers whose TSWs depend on user antenna, service type, and operational preferences. For example, a customer's TSWs applicable to use of a high-gain antenna (HGA) may be different from those applicable to use of a low-gain antenna (LGA). Another customer may prefer to schedule events in complete sunlight although events in partial sunlight and full shadow are acceptable.

Customers with scheduling preferences transmit multiple sets of TSWs, one set for each preference. Additionally, these customers submit primary and alternate requests: primary requests specify SSCs using the TSW set associated with the highest preference; alternate requests specify SSCs using TSW sets associated with corresponding lower preferences.

Consider a customer with

a. Preference for an event that occurs entirely in spacecraft sunlight.

b. Acceptability of an event in limited shadow when a full sunlight event cannot be scheduled.

c. Acceptability of an event in unlimited shadow when a partial sunlight event cannot be scheduled.

The customer addresses these preferences by

a. Transmitting three sets of TSWs: Set 1 for sunlight only, Set 2 for sunlight and limited shadow, and Set 3 for sunlight and unlimited shadow.

b. Specifying TSW-Set-ID 1 as the default for its SSC.

c. Submitting three requests, each with the same requested start time, start-time tolerances, and SSC. (The customer uses the same SSC for all three possibilities.)

    1. One primary request does not respecify the TSW-Set-ID.

    2. The first alternate request respecifies the TSW set to be TSW-Set-ID 2.

3. The second alternate request respecifies the TSW set to be TSW-Set-ID 3.

The NCCDS addresses customer preferences by first attempting to schedule the primary request. It attempts to schedule the first alternate request only if it fails to schedule the primary request. It attempts to schedule the second alternate request only if it fails to schedule both the primary and first alternate requests (see Figure 4–5).

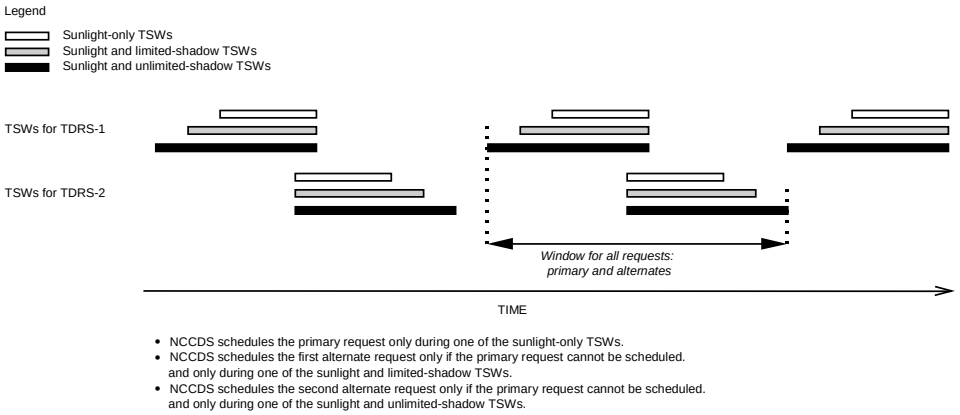


Figure 4–5. Scheduling with TSWs allows the customer to specify preferences within a scheduling window.

4.3.2.2.3 Validation of TSWs

NCCDS validates TSW messages for

a. Customer spacecraft.

b. TDRS operational name.

NCCDS validates individual TSWs within TSW messages for

a. Relationship with other TSWs in the same message. In particular, the TSWs must not overlap.

b. Relationship with the overall timespan of the message. In particular, the individual TSW must fall within the overall timespan.

c. Appropriateness of durations of individual TSWs based on prespecified maximum and minimum TSW durations for the customer.

4.3.2.2.4 Handling Impacts of Applying TSW Updates on Requests and Scheduled Events

NCCDS handles the impacts of applying TSW updates on requests and scheduled events in one of several different ways depending on the impact and the state of the request or the event.

a. TSW updates have no immediate effect on requests that have never been scheduled. However, the NCCDS bases subsequent attempts to schedule such requests on the updated TSWs rather than on the TSWs that were available when the requests were received.

b. Receipt of new TSWs triggers the wait list process. The NCCDS will attempt to schedule requests on the wait list using the new TSWs.

c. If new TSWs arrival while batch scheduling is in progress, the NCCDS alerts the operator that new TSWs that may apply to the batch schedules have arrived. The operator may review and rerun the schedules.

d. The NCCDS reviews each event on the active schedule to verify that it still fits in the new TSWs. If it does not, the NCCDS alerts the operator who reviews the event and may modify the event.

4.3.2.3 Schedules With Increased Effectiveness

The NCCDS supports the following capabilities to generate schedules with increased effectiveness:

a. Generating alternative schedules

b. Operator evaluation of alternative schedules

c. Conflict identification and conflict resolution

4.3.2.3.1 Generating Alternative Schedules

The NCC operator may generate alternative forecast schedules using the following capabilities:

a. Selecting or excluding sets of schedule requests.

b. Editing schedule requests.

c. Reordering scheduling priorities.

4.3.2.3.2 Operator Evaluation of Alternative Schedules

The NCCDS provides the operator with displays that allow for comparisons between multiple sets of batch-generated schedules. For each customer, these comparisons shall allow the operator to evaluate the schedules in terms of the number of events scheduled relative to the number of events requested and relative to the customer's level-of-support parameters.

4.3.2.3.3 Conflict Identification and Conflict Resolution

NCCDS supports operator-assisted conflict resolution necessary for adjusting effective initial schedules to ensure that every customer has the best possible schedule. Operator-assisted conflict resolution is also necessary for resolving conflicts when a request arrives during the active period after an initial forecast schedule has been finalized and activated. NCCDS supports conflict

resolution by identifying to the operator all conflict information, and allowing the operator to select from all potentially feasible resolution strategies.

The NCCDS provides the operator with the following capabilities that may be used to resolve conflicts:

a. Delete or replace conflicting scheduled events

b. Edit requests to:

    1. Reduce requested service durations.

    2. Change requested start times.

    3. Use different resources.

4.3.2.4 Enhancements To Improve Operability

NCCDS 1998 introduces several capabilities that were not available in earlier versions of the NCCDS:

a. Support for launch slips and for unanticipated resource changes

b. Replace requests

c. Wait-listed requests

d. TDRSS Unscheduled Time information

e. Capability to store and edit all requests

f. Retransmission of schedule messages

g. Coherent scheme for identifying requests and events

4.3.2.4.1 Support for Launch Slips and Unanticipated Resource Changes

In general, it is highly desirable to have the customer MOC fully involved in all schedule changes. However when that is not feasible, the NCCDS 1998 includes capabilities that allow the NCC operator to effect large scale changes to the active schedule such as are associated with launch slips and unanticipated resource changes. These capabilities include:

a. Editing of selected groups of requests or active events to modify:

    1. Nominal event start times.

    2. TDRS specifications.

    3. Customer-specified request priority.

b. Direct inclusion of active events in batch scheduling.

c. Adjustment of the boundary between the batch scheduling and the automatic schedule update phases of the active period. This allows the operator to minimize the automatic

schedule update phase so that nearly all of the active schedule can be updated by use of batch scheduling which allows for greater operator control.

4.3.2.4.2 Replace Requests

NCCDS 1998 provides customers with the replace request capability. Previously, replacement of an active event was a two-step process in which customers would first submit a delete request and then submit an add request. This always involved some risk that the original resources would not be available when the new add request was processed.

NCCDS 1998 allows customers to submit replace requests instead. A replace request can replace either a yet-to-be-scheduled request or a scheduled request. A replace request referring to a yet-to-be-scheduled request simply results in replacing the yet-to-be-scheduled request. A replace request referring to a scheduled request implies deletion of the scheduled event only after the replace request is successfully scheduled. The specification of a replace request includes identification of the referenced request. The replace request capability accommodates changes to customer requests with decreased customer and operator effort.

4.3.2.4.3 Wait-Listed Requests

NCCDS supports the new capability of wait-listing declined requests. A wait-listed request is retained for future processing until a specified expiration time. When resources become available due to deletion of previously scheduled events or TSW updates, the NCCDS attempts to schedule the wait-listed requests.

The customer can wait-list a request by either submitting a wait-list request that refers to a declined request and that specifies an expiration time, or by setting the wait-list parameter in the original request. If the later method is used, the expiration time is based on customer information in the NCCDS database.

4.3.2.4.4 TDRSS Unscheduled Time Information

NCCDS generates TDRSS Unscheduled Time (TUT) information on a periodic basis and makes it available to customers. TUT information provides an indication of time periods within the active schedule that are available for the scheduling of additional customer services. Three types of TUT information (i.e., SA, MAF/SMAF, and MAR/SMAR) are generated for each TDRS. TUT information is provided to customers via a WWW server, or via e-mail for any customers who cannot access the WWW server. Use of TUT information improves the effectiveness of requesting additional SN services during the active period.

4.3.2.4.5 Capability To Store and Edit All Requests

NCCDS 1998 retains nearly all schedule requests until certain purge criteria are meet. Up until a request is purged, the NCC operator may edit the request and use the edited version in scheduling.

NOTE

For backwards compatibility with certain legacy operations procedures, it is necessary to discard some requests in order to preserve unique identification of requests.

4.3.2.4.6 Retransmission of Schedule Messages

NCCDS 1998 supports retransmission of any type of schedule message, when appropriate. An NCC operator initiates such a retransmission upon receipt of information indicating that a customer or SN facility has lost or failed to receive a schedule message.

4.3.2.4.7 Coherent Scheme for Identification of Requests and Events

NCCDS 1998 includes a coherent scheme for identifying requests and events. NCCDS uses request identifiers to generate event identifiers. This allows the NCCDS, the NCC operators, and the customers to easily associate the events and requests referenced in schedule messages and replace requests with the corresponding initial requests.

4.3.3 Acquisition Data Handling

Customers and ground terminals require the use of acquisition data to properly point their antennas and to compensate for Doppler shifts that arise from the spacecraft’s velocity relative to the TDRS. Acquisition data consists primarily of state vectors (position and velocity at a specific point in time, the epoch) in the form of IIRVs for customer transponders. Generally, these transponders are located on customer spacecraft in space. Prior to launch or after landing, the transponders may be located on customer spacecraft on the Earth's surface. The NCC also supports a special class of customers known as permanent Earth stations. Permanent Earth stations, such as the Bilateration Ranging Transponder System (BRTS), have transponders located permanently on the Earth's surface.

TDRS and orbiting customer spacecraft are supported by free flight vectors. Transponders located on the Earth's surface are supported by stationary vectors. Spacecraft executing maneuvers, including launch and reentry maneuvers, are supported by sequences of state vectors of specified types. Balloons and airplanes can be supported by stationary vectors or by maneuver sequences. The NCC supports launch slips by altering the vector epochs in the NCCDS and WSC, and notifying the FDF and any impacted customers.

The primary NCCDS acquisition data handling capabilities include the receipt, storage, and transmission of IIRVs for both customer spacecraft and TDRSs. In addition, delta-T messages may be sent to the ground terminals to adjust the epoch times of vectors during launch slips for a specified spacecraft.

Management of stored vector inventories under operator control facilitates operations (e.g., support of shuttle launch contingencies) by keeping alternative vector sets available, if needed. Vector editing capabilities (e.g., vector entry, modification, deletion) facilitate network testing by eliminating the need for FDF participation in many cases. Individual vectors or maneuver

sequences can be copied and modified, primarily for test purposes. Operators can select individual vectors, maneuver sequences, or groups of vectors to be deleted.

Vectors are transmitted to the ground terminals in several operational modes: manual, semiautomatic, and two variations of throughput—normal and real-time. While manual mode permits the operator to transmit vectors individually, semiautomatic mode transmissions are based on predefined rules as managed by the operator.

Throughput mode transmission generally results in the immediate transmission of newly received vectors that are updates to previously transmitted vectors. More specifically, a newly received vector qualifies for throughput transmission if it would have been included in a previous semiautomatic mode transmission had it been available at that time. In normal throughput, the operator is provided with the option to review the vectors before allowing their transmission. In real-time throughput, there is no operator review and there are minor variations in protocols to ensure expedited transmission to WSC. All vector transmissions may be terminated by the operator.

Enhanced operator displays and alerts provide NCC operators the capability to review all acquisition data and determine what data have been received from each source and transmitted to each destination. Vectors can be selected for review individually or in groups filtered by SICs, vector types, epoch times, receipt or transmission times, sources, or destinations. The operator can review the result of WSC vector processing ground rules and epoch time adjustments on the vectors transmitted to WSC.

Vectors in the NCCDS are managed in two categories. The primary category is intended for current operational use. The secondary category is intended for vectors that have been superseded by updated data. Operators have the capability to reassign vectors from one category to the other. Vectors received by the NCCDS are always categorized initially as primary. Only primary vectors can be transmitted automatically. All other functions work equally for primary or secondary vectors.

Operator alerts result when vector transmissions begin and terminate normally, a vector fails to be acknowledged, a vector is rejected by the ground terminal, or a delta-T rejection is received.

4.3.4 Real-time Control and Monitoring

The NCCDS provides capabilities to control and monitor SN services in near-real time. These capabilities include

a. Reconfiguration of ongoing services.

b. Dissemination of user performance data.

c. Network monitoring.

d. Dissemination of postevent data (return channel time delay measurements and time transfer measurements).

Section 5. NCCDS Operations Scenarios

5.1 Introduction

The introduction of flexible scheduling necessitates changes in NCC operations. NCCDS allows scheduling of SN resources for their efficient and effective use even when changes in resource availability and demand occur. The scheduling capabilities and concepts supported by the NCCDS, as described in Section 4.3, affect existing NCC scheduling operations. This section describes the following NCC operations:

a. Scheduling operations

    1. SN resource data specification

    2. Customer data specification

    3. Forecast scheduling

    4. Active scheduling

b. Acquisition data handling

Many of these functions were supported by previous version of the NCCDS. However, NCCDS 1998 provides enhancements and changes to this support. Other NCC operations remain unchanged from previous versions of the NCCDS. Thus, no scenarios are presented here for real-time control and monitoring operations involving processing of ground control message requests and user performance data messages.

5.2 Scheduling Operations

Figure 5–1 shows the timeline of NCCDS scheduling operations relative to the time period during which SN service is provided to the customers. The time intervals are shown as 1-week periods but may be any length subject to a maximum total of 28 days for the forecast and active period operations. The actual lengths of these time periods are determined by NCC operational procedures.

5.2.1 SN Resource Data Specification Operations

As shown in Figure 5–1, NCC operators specify and modify resource data when necessary and without any time restrictions. Figure 5–2 shows the operational scenario for SN resource data specification. An NCC operator with designated privileges uses the NCCDS operator interface capabilities to specify and modify resource data that are necessary for scheduling SN resources. The resource data includes the schedulable SN resources and their availability. The NCC operator modifies resource data as soon as the data becomes known or available. This ensures that the generated schedules correspond to actual resource availability.

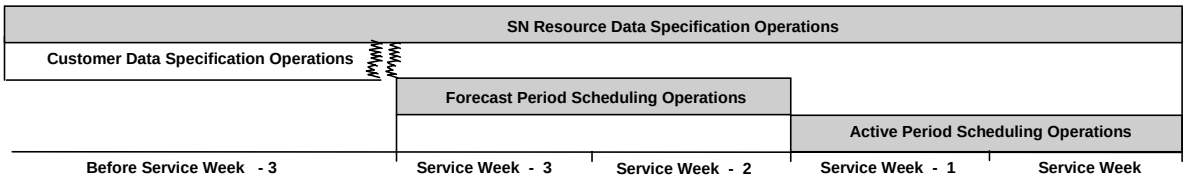
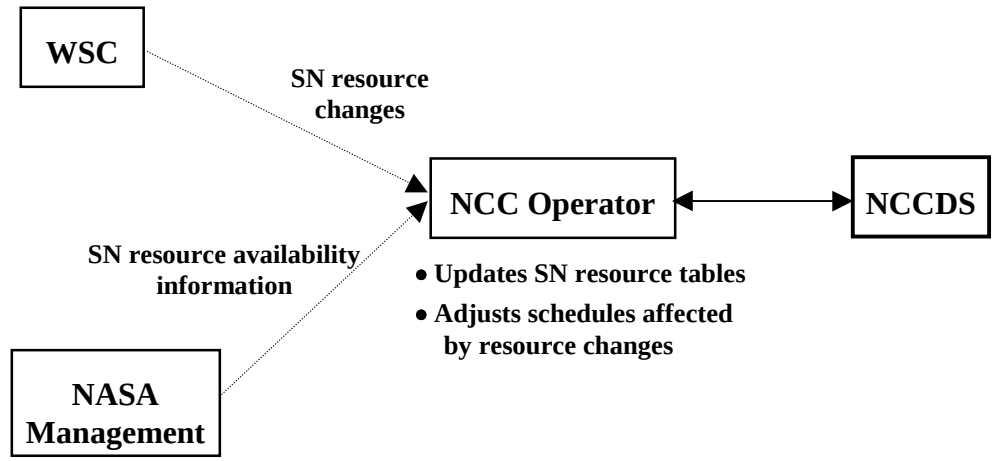


Figure 5–1. NCCDS scheduling operations are conducted relative to the time period in which SN resources are provided.



Dotted line denotes nonelectronic information flow

Figure 5–2. Operations for SN resource data specification

There are two types of resource data: time-independent (static), and time-dependent (dynamic). The NCC operator specifies and updates time-independent resource data infrequently. Some examples of static resources data are

a. TDRS ID.

b. Resource and service setup times.

c. Resource capacities.

The NCC operator specifies and updates time-dependent resource data as a time-ordered table to accommodate changing network operating configuration and conditions. Some examples of time-dependent resource data are

a. Mapping between TDRS operational name and TDRS ID.

b. Mapping between TDRS operational names and SGLTs.

c. Availability of each service type using SA-1 for each SGLT.

d. Availability of each service type using SA-2 for each SGLT.

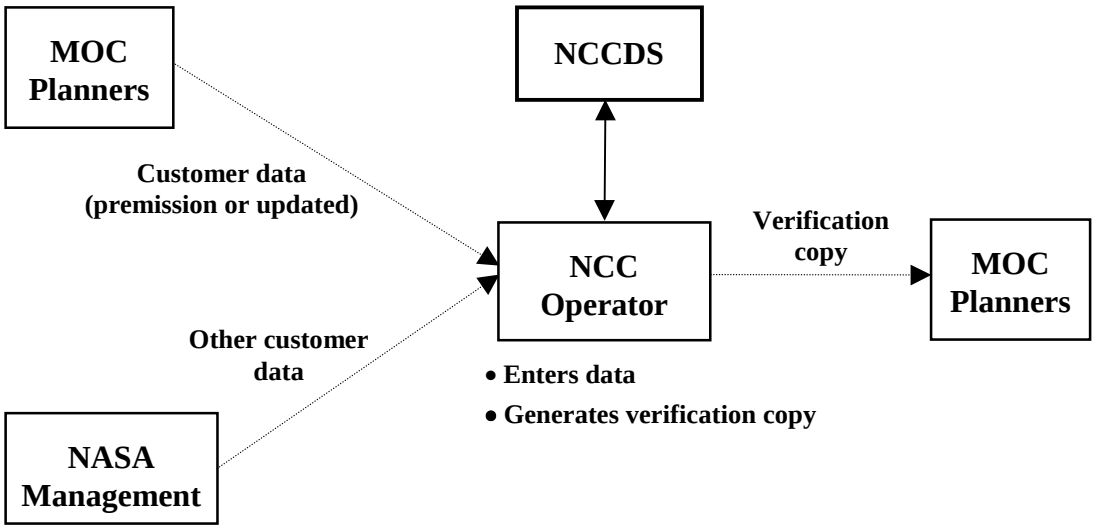
e. Availability of MAF and SMAF for each SGLT.

f. Available number of MAR and SMAR links for each SGLT.

Some resource data modifications involve resource availability for time periods in which the schedule has already been generated. When such modifications occur, the NCC operator performs necessary scheduling operations to modify previously generated schedules to ensure their continued validity.

5.2.2 Customer Data Specification Operations

Although customer data can be modified at any time, the modifications must be in place prior to forecast scheduling operations for a particular service week in order to apply to all events in that service week. NCC operators specify and modify customer data nominally at least 3 weeks before the beginning of the service week (see Figure 5–1). Figure 5–3 shows the operational scenario for customer data specification. An NCC operator with designated privileges uses the NCCDS operator interface capabilities to specify and modify the customer data necessary for scheduling SN services for that customer. Customer data comprises parameters associated with an individual customer.



Dotted line denotes nonelectronic information flow

Figure 5–3. Operations for customer data specification

The NCC operator specifies and modifies selected customer data based primarily on information provided by the customers. The NCC operator specifies and updates certain other customer data based primarily on SN management and operational policies or specification by NASA management.

Some examples of customer data based primarily on information provided by the customers are

a. Spacecraft parameters.

b. Authorized user list.

c. Valid service types and associated default parameters.

d. Schedule distribution list.

e. Default event freeze time.

f. SSCs.

g. Prototype events.

h. TSW duration validation criteria.

Some examples of customer data based primarily on SN management and operational policies or specification by NASA management are

a. Spacecraft name.

b. VIC.

c. PN codes.

d. Authorized TDRSs for each SUPIDEN.

e. User passwords.

f. Committed levels of support.

   1. Amount of each type of service for each priority level

   2. How the service is to be provided in terms of a distribution across time

g. Mission priority.

5.2.3 Forecast Scheduling Operations

As shown in Figure 5–1, NCC operators perform forecast scheduling operations during the first 2 weeks of a 3-week period before the beginning of the service week. An NCC operator with designated privileges performs forecast scheduling operations. NCC operators frequently communicate by phone with customers to assure that SN contacts are scheduled consistent with their needs.

Forecast scheduling operations involve the following general sequence of operations:

a. Receipt and validation of TSWs and schedule requests

b. Creation of an effective forecast schedule

c. Activation of the forecast schedule and transmission of schedules to the customers

5.2.3.1 Receipt and Validation of TSWs and Schedule Requests

NCCDS automatically receives and validates TSWs and schedule requests from the customers during the first week of the 2-week period of forecast scheduling operations. Customers may transmit schedule requests either before or after transmitting TSWs. If necessary, the NCC operator verbally coordinates the request and TSW transmission with the customers.

5.2.3.1.1 Receipt and Validation of TSWs

Figure 5–4 summarizes TSW operations. For customers who request that the NCCDS use TSWs in the scheduling process, the customers or their designated facilities generate and electronically transmit the TSWs to the NCC. TSWs specify periods of time during which the customer can use SN services. TSWs reflect all relevant RF visibility (i.e., Earth occultation, antenna masking, other spacecraft-specific factors) and mission-specific scheduling constraints. As stated earlier, customers may transmit TSWs either before or after transmitting schedule requests. However, transmitting the TSWs before transmitting the schedule requests is preferred because it allows the NCCDS to verify that the schedule requests fit within the TSWs when the schedule requests are received.

NCCDS automatically validates TSWs as stated in 4.3.2.2.3.

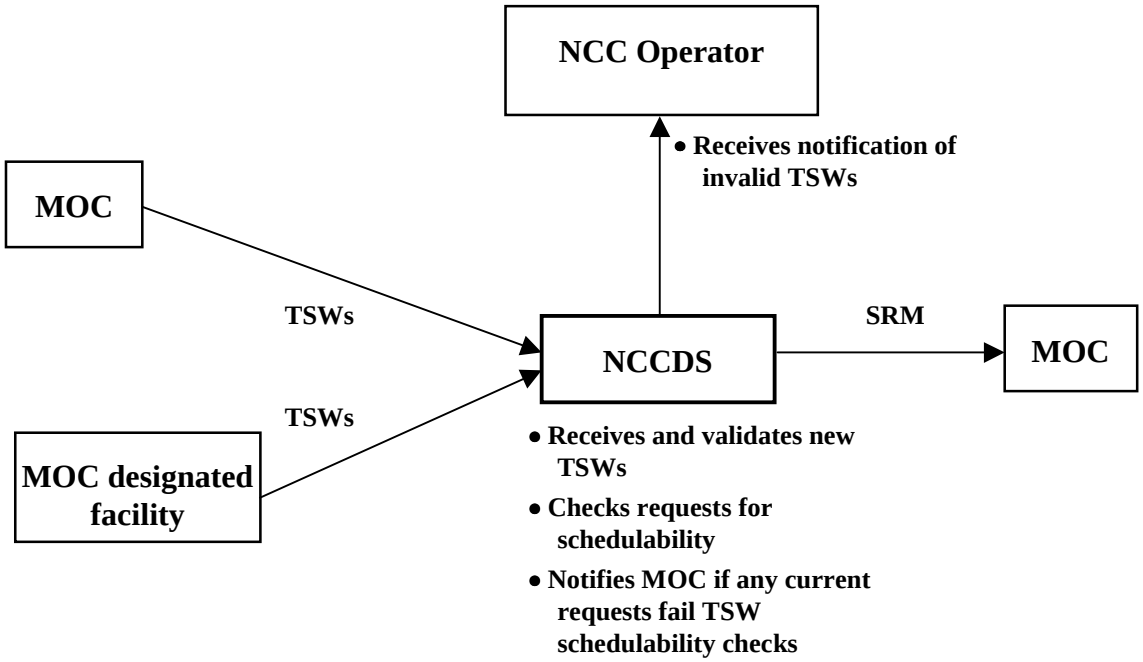


Figure 5–4. TSW operations

NCCDS automatically stores valid TSWs for periods with no previously received TSWs. NCCDS also uses these valid TSWs to automatically validate requests for schedulability as they

are received. NCCDS transmits an SRM to the customer that indicates validation failure for each stored forecast schedule request that fails a TSW schedulability check.

NCCDS alerts the NCC operator upon receipt of TSW updates that overlap with previously received TSWs. The NCC actions in response to TSW updates are as previously discussed in 4.3.2.2.4.

5.2.3.1.2 Receipt and Validation of Schedule Requests

Figure 5-5 shows the operational scenario for schedule request specification. Customers formulate flexible schedule requests that specify flexibility of schedulable resources (e.g., TDRSs, event start times, service start times, and service durations) before transmitting these requests to the NCC. Customers may use an UPS to formulate and electronically submit their flexible schedule requests to the NCC. UPS also offers its customers the added capability to specify and expand recurring requests into specific flexible schedule requests using customer-specified expansion algorithms under the customer's direct control.

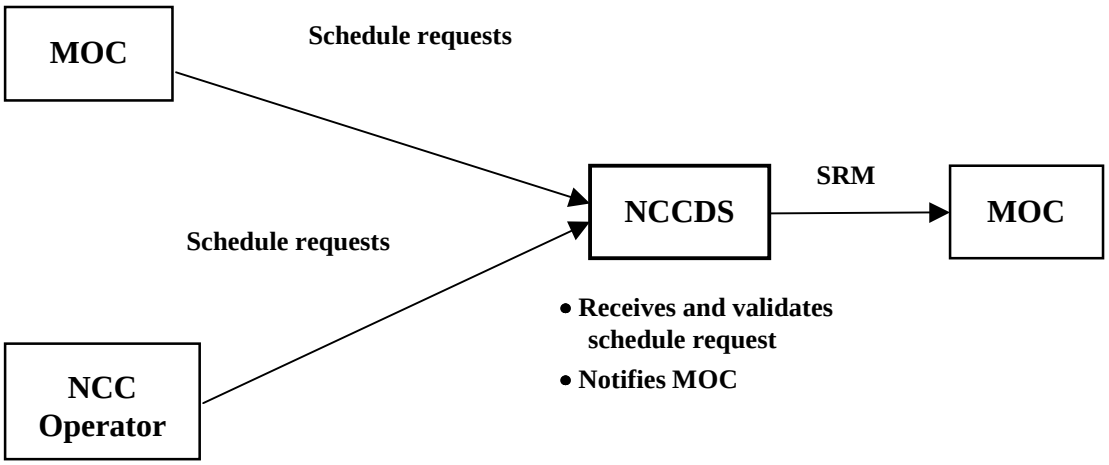


Figure 5–5. Operations for schedule request specification

In addition, an NCC operator may create and submit specific schedule requests using the NCCDS operator interfaces to edit existing schedule requests.

NCCDS automatically receives, stores, and validates all requests to ensure that validation criteria are satisfied. Some examples of validation criteria are

a. Authorized user.

b. Authorized support identifications.

c. Valid SSCs for the customers.

d. Valid prototype event.

e. Consistency with scheduling ground rules as specified in 451-SRD-NCCDS/1998.

Additionally, the NCCDS automatically checks specific schedule requests for schedulability relative to previously received TSWs.

For customer-transmitted specific schedule requests, NCCDS transmits SRMs to the customer that indicate the result of the request validation, and when appropriate, include a reason for validation failure. For a specific request submitted by the NCC operator, NCCDS validates it when entered and allows the operator to correct it for validation. Alternatively, the operator can store it for later editing. An NCC operator may edit invalid requests, including those transmitted by customers, and resubmit them for validation and storage.

5.2.3.2 Creation of an Effective Forecast Schedule

Figure 5–6 summarizes the operations for creating an effective forecast schedule. The NCC operator creates an effective forecast schedule by following a sequence of operations:

a. Generation of alternative forecast schedules.

b. Selection of the most effective forecast schedule based on evaluation of alternative forecast schedules.

c. Augmentation of the selected forecast schedule using operator-assisted conflict resolution.

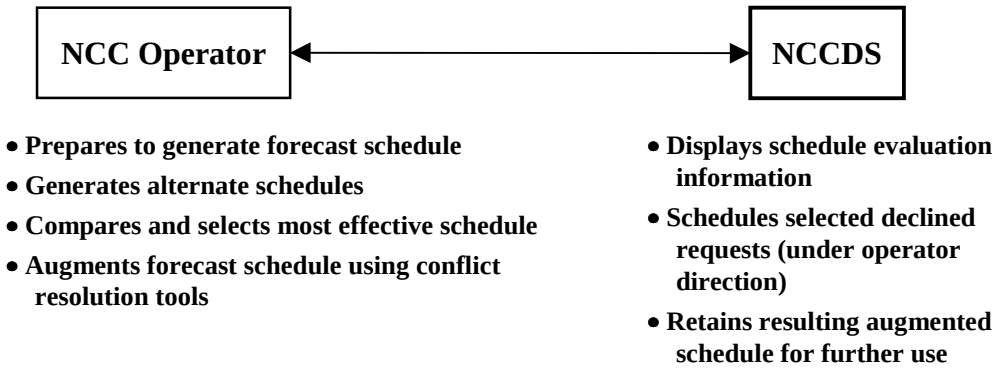


Figure 5–6. Operations within the NCC for creating an effective forecast schedule

5.2.3.2.1 Generation of Alternative Forecast Schedules

An NCC scheduling operator uses the NCCDS operator interface capability to review the list of stored requests to verify that all the requests expected for the forecast period have been received and successfully validated. For customers with requests requiring use of TSWs, the NCC operator verifies that relevant valid TSWs have been received. The operator may verbally coordinate with customers for last-minute transmission of schedule requests and TSWs.

After confirming that all requests and TSWs have been received and validated, the NCC operator uses the NCCDS capabilities to review and possibly rearrange the scheduling priorities list used

in generating the forecast schedules. The scheduling priorities list is initialized to be a composite of the customer-assigned priorities and mission priorities based on the customer-assigned priorities concept described in 4.3.2.1.7. Depending on the characteristics and the type of support requested by different customers, the NCC operator rearranges the scheduling priorities list.

The NCC operator generates several alternative schedules, selecting a different set of requests, editing them, or rearranging the schedule priorities list for each schedule, as necessary. Each scheduled event in each alternative schedule maintains flexibility consistent with the original request and other scheduled events.

5.2.3.2.2 Selection of the Most Effective Forecast Schedule

The NCC operator compares the generated alternative forecast schedules to select the most effective forecast schedule. The NCC operator uses the NCCDS capabilities described in 4.3.2.3.2 to compare alternative forecast schedules based on several different evaluation criteria. These comparisons permit the operator to perceive the advantages and disadvantages of the alternative schedules.

The NCC operator selects the most effective initial forecast schedule using the operator's own judgment in conjunction with evaluation criteria are provided by the NCCDS.

5.2.3.2.3 Augmentation of the Selected Forecast Schedule

The NCC operator augments the selected forecast schedule, using operator-assisted conflict resolution, to ensure that it provides the best possible schedule to each customer. Since the procedures followed by the NCC operator depend on the specific displays actually provided by the NCCDS, only representative operational procedures are described here.

The operator uses NCCDS-provided evaluation displays to identify problems within the selected forecast schedule. First, the NCC operator identifies customers with less satisfactory schedules. The operator then reviews the schedule of each such customer with a less than satisfactory schedule to identify time periods that require augmentation of the schedule. In addition, the operator consults with the customer to identify any requests that require special consideration.

For these periods, the operator uses conflict-resolution techniques to schedule some of the requests, which had not been scheduled in the selected initial forecast schedule. The operator resolves conflicts for the initially unscheduled requests using the NCCDS capability for conflict identification and conflict resolution, described in 4.3.2.3.3.

5.2.3.3 Activation of Forecast Schedule and Transmission of Flexible Schedules to Customers

Figure 5–7 summarizes the activities associated with activation of the forecast schedule. After resolving as many conflicts as possible, the NCC operator activates the augmented forecast schedule. Under control of the NCC operator or on the basis of predefined rules, NCCDS transmits SRMs (for all requests) and USMs (for the scheduled events) to destinations designated for the customer. The transmitted USMs may be either fixed or flexible. The flexible USM includes specific information about scheduled resources and times. However, the resources and

times specified are subject to change within the flexibility specified in the request when the NCC freezes the event. Such changes in the event do not include its deletion, or reduction of any service durations.

NOTE

As part of the protocol for establishing the communications connection to receive USMs and SRMs, MOCs using TCP/IP must send a Schedule Results Request (SRR) message to the NCCDS. For MOCs using Nascom 4800 bb protocol, the NCCDS internal generates an SRR message.

NOTE

Legacy or other customers unable to use scheduling flexibility receive only fixed USMs in this and subsequent scenarios.

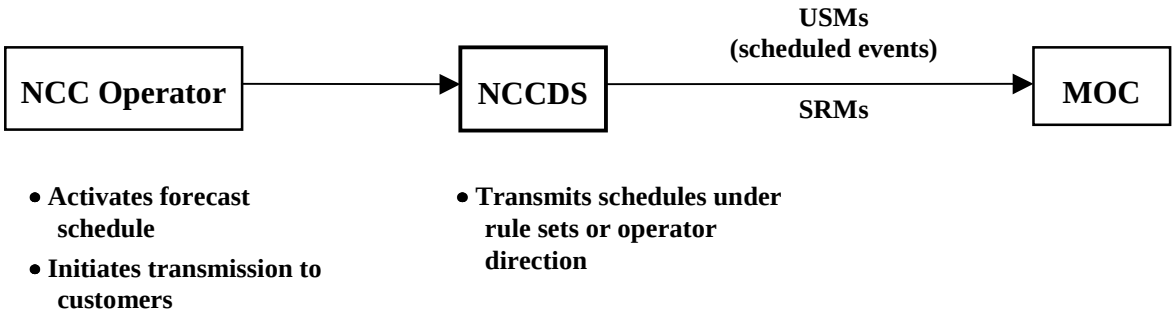


Figure 5–7. Activities associated with activation of forecast schedule

5.2.4 Active Scheduling Operations

Active period scheduling operations encompass the following operations as needed:

a. Freezing of the flexible scheduled events and transmission of the fixed USMs to the customers

b. Transmission of the frozen schedules to SN elements such as the STGT and WSGT

c. Schedule maintenance

5.2.4.1 Freezing of Flexible Scheduled Events

The NCCDS freezes the flexible scheduled events and transmits fixed USMs (Figure 5–8), at the earliest of

a. Expiration of the request's schedule freeze time as specified explicitly in the request or implicitly by the customer’s default freeze time.

b. Transmission of events to SN elements.

The NCCDS satisfies, to the maximum extent possible, the requested nominal start times and service durations while maintaining the validity of the current schedule, which usually contains some frozen requests and some flexible requests. NCCDS transmits fixed USMs for the frozen events, with fixed start times, resources, and service durations. These USMs are transmitted either under control of the NCC operator or on the basis of predefined rules to the destinations designated for that customer.

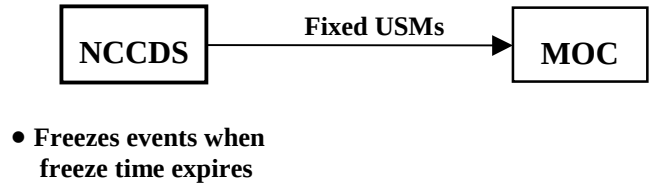


Figure 5–8. Freezing of flexible scheduled events

5.2.4.2 Transmission of Schedules to SN Elements

The NCCDS transmits (Figure 5–9) schedule messages for events with fixed start times, resources, and service durations to SN elements and other entities (e.g., the WSC, SDPF) under complete control of the NCC operator or on the basis of predefined rules.

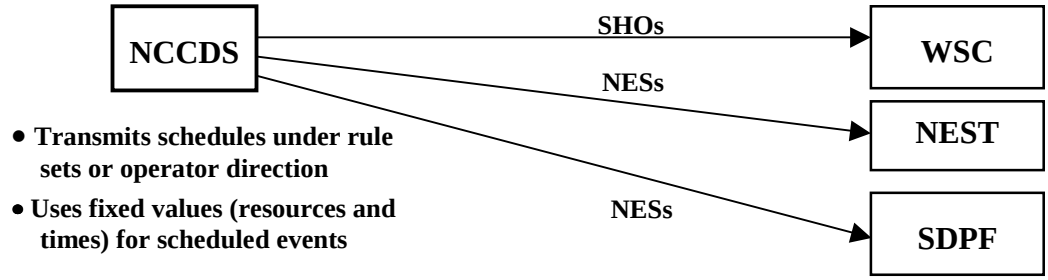


Figure 5–9. Transmission of Schedules to SN Elements

5.2.4.3 Schedule Maintenance

Although the NCC operator may be involved in all aspects of active schedule maintenance, the NCCDS can automatically update the schedule in response to

a. Schedule delete requests.

b. Wait-listed requests.

c. Late-arriving schedule add requests.

d. Replace requests.

Upon receipt of TSW updates, the NCCDS will determine whether schedule updates could be needed and will alert the operator who will determine whether to perform the updates.

In all cases, the NCC operator has a lead role when the active schedule must be updated in response to

a. Shuttle launch slips.

b. Unanticipated resource changes.

5.2.4.3.1 Schedule Delete Requests

Figure 5–10 summarizes the operations associated with schedule delete requests. NCCDS receives and validates schedule delete requests, then removes the associated scheduled events from the schedule and transmits an SRM to the customer indicating event deletion. If the affected events have already been transmitted to other entities such as WSC, NCCDS transmits appropriate messages indicating event deletion to the affected entities. When an event is deleted, NCCDS immediately attempts to schedule wait-listed requests for the resources made available by the deleted events.

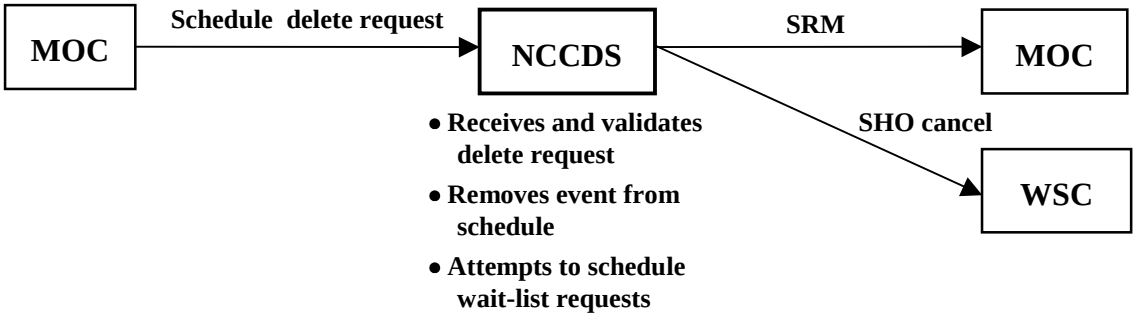


Figure 5–10. Operations associated with delete requests

5.2.4.3.2 Wait-List Requests

The NCCDS automatically receives and validates wait-list requests and changes the status of the declined request specified by the wait-list request to wait-listed status. The NCCDS attempts to schedule wait-listed requests before their expiration times when resources become available for any reason, including TSW updates. The NCCDS performs the same operations when a wait-listed request is scheduled as those performed when a late-arriving schedule add request is scheduled automatically. Figure 5–11 summarizes the operations associated with wait-list requests.

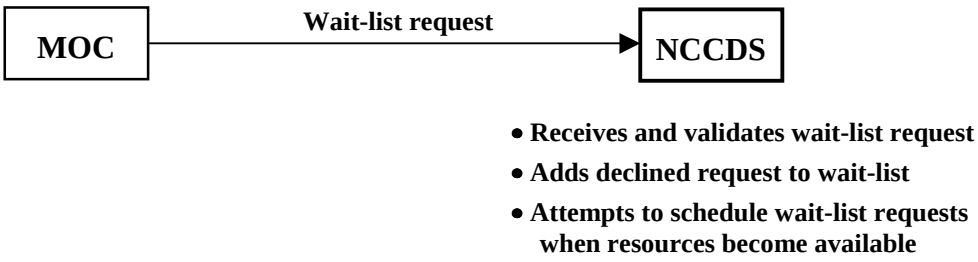


Figure 5–11. Operations associated with wait-list requests

5.2.4.3.3 Late-Arriving Schedule Add Requests

Figure 5–12 summarizes the operations associated with late-arriving schedule add requests. The customer has the option of using TDRSS Unscheduled Time (TUT) information to identify suitable unscheduled time periods on particular TDRS antennas. Based on this information the customer submits one or more schedule add requests. The NCCDS receives and validates such late-arriving schedule add requests. Depending on the requested event start time of the late-arriving schedule add request, NCCDS either attempts to automatically schedule the request immediately or stores it for active period batch scheduling under operator control at a later time.

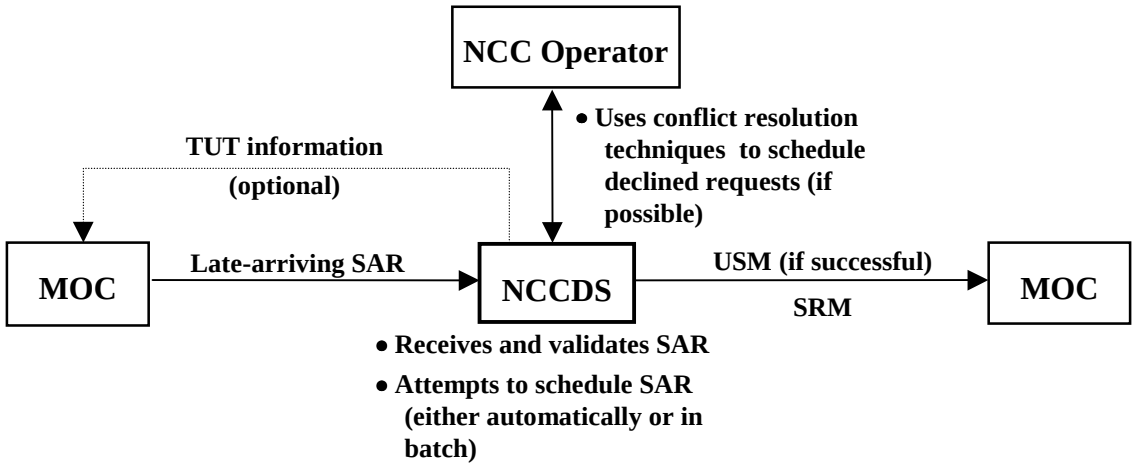


Figure 5–12. Operations associated with late-arriving schedule add requests

When NCCDS fails to automatically schedule a late-arriving schedule add request because of conflicts with previously scheduled events, the NCC operator may attempt to schedule the request manually using the NCCDS capability for operator-assisted conflict resolution discussed in 4.3.2.3.3.

When a late-arriving schedule request is automatically scheduled or first fails and then is subsequently scheduled through operator-assisted conflict resolution, the NCCDS immediately freezes the scheduled event. The NCCDS then transmits relevant schedule messages to all appropriate destinations.

For late-arriving schedule requests that fall within the batch scheduling phase of the active period, the NCC operator initiates the batch scheduling process. The NCC operator may use the NCCDS operator-assisted conflict-resolution capability to manually schedule some of the requests that fail to be scheduled by batch scheduling. NCCDS transmits SRMs (for all requests) and USMs (for scheduled events) to the customer-designated destinations.

5.2.4.3.4 Replace Requests

Figure 5–13 summarizes the operations associated with replace requests. The NCCDS automatically receives, validates, and attempts to accommodate replace requests. The NCCDS responds to replace requests with one of the following actions:

- When a replace request replaces a request yet to be scheduled, NCCDS sends an SRM to the customer indicating deletion of the replaced request. Additionally, depending on the requested event start time of the replace request, NCCDS either attempts immediately to schedule the replace request automatically or stores it for operator-controlled active period batch scheduling at a later time.

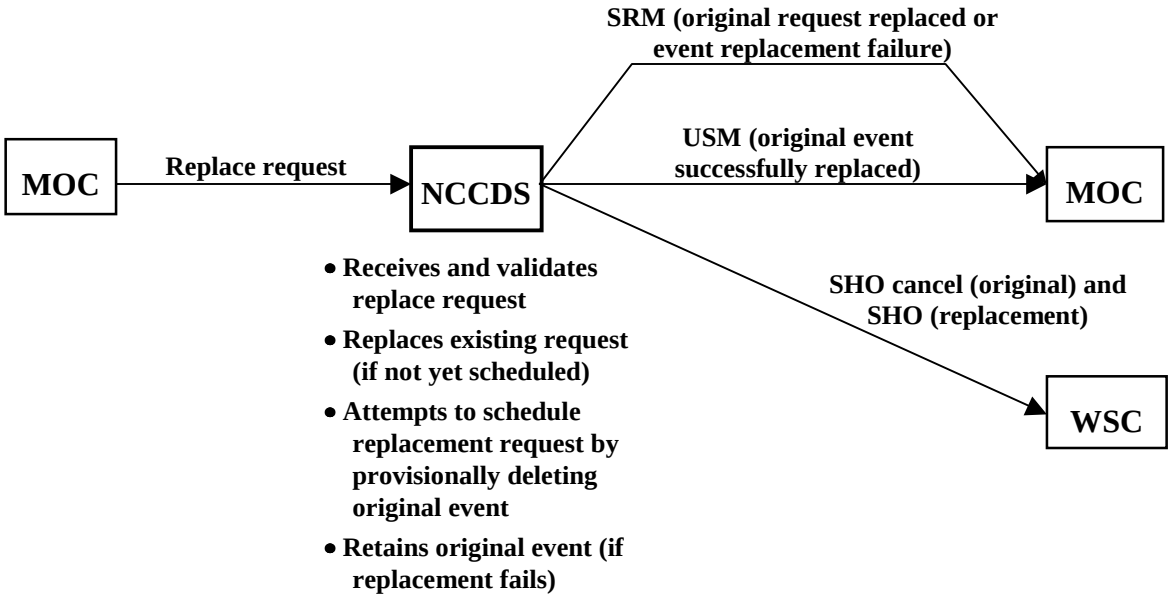


Figure 5–13. Operations associated with replace requests

- When a replace request applies to an already scheduled event, the NCCDS immediately attempts to schedule the replace request by assuming that the resources allocated to the replaced event are available to be used by the replace request. If the replace request is successfully scheduled, NCCDS transmits schedule messages relevant to the affected

requests to appropriate destinations. If the replace request is not scheduled, NCCDS transmits a schedule result message to notify the customer.

5.2.4.3.5 TSW Updates

Figure 5–14 summarizes the operations associated with TSW updates. When TSW updates for the active period arrive, the NCCDS automatically checks the schedulability of all active period requests and events for the customer associated with the TSW updates. For scheduled events that fail the schedulability check, the NCCDS allows the operator to

a. Delete or modify these impacted events.

b. Allow the impacted events to remain on schedule.

The NCCDS then transmits relevant status messages to appropriate destinations. Additionally, the NCCDS attempts to schedule wait-listed requests and transmits relevant schedule messages for newly scheduled events to appropriate destinations.

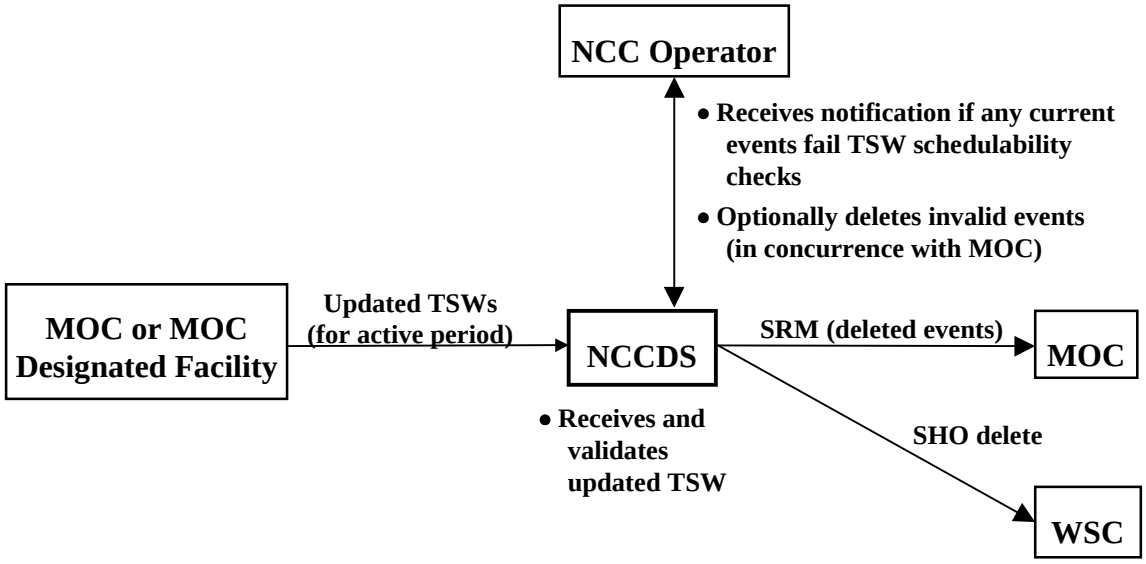


Figure 5–14. Operations associated with TSW updates

5.2.4.3.6 Shuttle Launch Slips

The following paragraphs describe an NCC scheduling operational scenario for responding to slips of scheduled launches. Although the paragraphs specifically reference the shuttle, this scenario is applicable to other launch vehicles. Figure 5–15 provides an overview of operations for responding to launch slips.

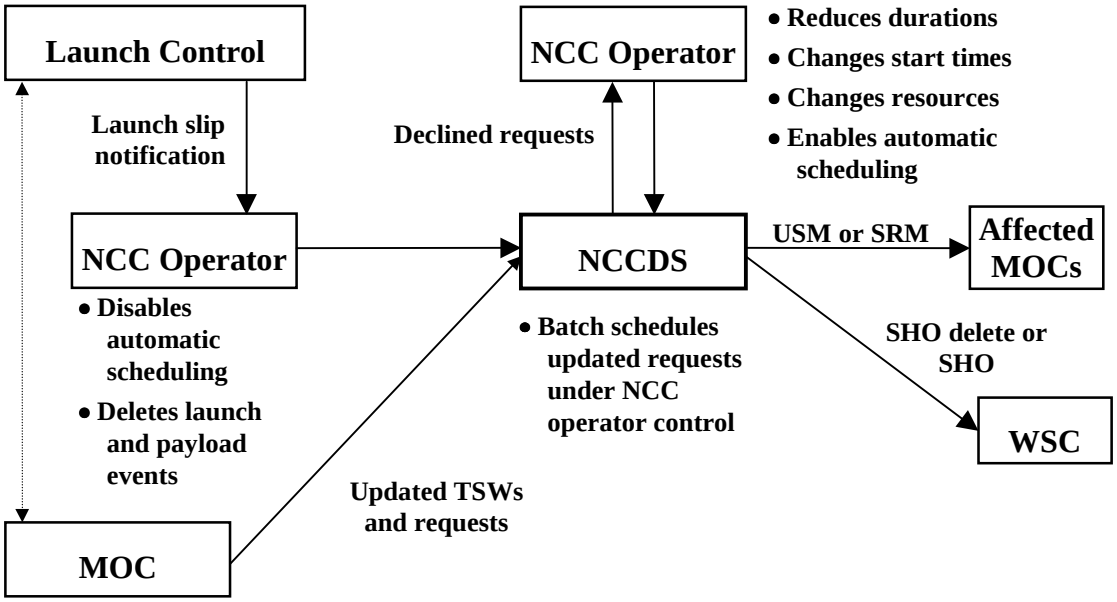


Figure 5–15. Operations for responding to launch slips

NCC operators use NCCDS rescheduling tools to respond to shuttle launch slips with the following sequence of NCC operations:

a. When STS launch control decides to delay the launch, they notify the NCC about the amount of launch slip.

b. The NCCDS applies updated TSWs if received from the STS mission control.

c. The NCC operator disables automatic scheduling of active period and wait-listed requests for the time period starting with the new planned launch time.

d. The NCC operator uses the NCCDS event delete capability to remove all shuttle and payload events, as a group, from the schedule.

e. The NCC operator uses the NCCDS edit capability to time shift the start times of all shuttle and payload requests.

f. The NCC operator uses the NCCDS batch scheduling capability to attempt to schedule the edited requests. This batch scheduling effort attempts to schedule the shuttle and payload requests while allowing the other customers' flexible events to move within their original flexibilities. This batch scheduling results in no deletions of previously scheduled events. However, some of the shuttle events may remain unscheduled.

g. The NCC operator uses the NCCDS conflict-resolution capability to schedule the shuttle requests that remain unscheduled.

    1. Initially, the operator uses appropriate batch conflict-resolution strategies on scheduled events of other customers. Two such strategies include reducing service

duration of scheduled events and minimizing service duration of scheduled events. As a result of selecting these strategies, service durations of scheduled events are reduced only to the extent necessary to allow successful shuttle events. No scheduled events of these other customers are deleted during this stage of the process.

2. Subsequently, the operator continues conflict resolution with higher impact strategies such as deleting other customers' scheduled events, reducing the duration of frozen scheduled events, and minimizing service duration of shuttle and payload requests.

h. When the NCC operator is satisfied with the schedule, the operator allows the NCCDS to transmit appropriate schedule messages to all the affected customers and entities.

i. The NCC operator enables automatic scheduling of all active period and wait-listed requests.

NOTE

The NCC operator may respond to launch slips by working first with requests that have near-term starting times before working with those starting later.

5.2.4.3.7 Unanticipated Resource Changes

NCCDS responds to unanticipated resource changes with the following sequence of significant operations:

a. The NCC operator makes changes to SN resource data based on information received automatically by the NCCDS in SLR messages, or on information received verbally, by fax, or by e-mail from the SN elements.

b. The NCC operator uses the NCCDS capability to check the schedulability of all events with respect to the updated availability of resources.

c. The NCC operator uses the NCCDS capability to identify all impacted events.

d. The NCC operator uses the NCCDS event delete capability to delete all impacted events from the schedule.

e. The NCC operator wait-lists all the requests associated with the events recently deleted.

f. The NCCDS attempts to schedule wait-listed requests immediately and later when resource availability changes occur.

g. The NCC operator may use the NCCDS conflict-resolution capability to manually schedule some of the wait-listed requests.

h. The NCCDS transmits relevant schedule messages to appropriate destinations as necessary.

5.3 Acquisition Data Handling

Figure 5–16 provides an overview of acquisition data handling operations. Acquisition data consists primarily of state vectors that contain accurate values for the position and velocity of an orbiting spacecraft at a specific epoch (time) for use in predicting its future orbit. These vectors are provided in the form of IIRVs for customer and TDRS transponders. The MOC or FDF generates acquisition data based on ground surveys, mission plans, and spacecraft ephemerides derived from tracking data. Each customer determines the schedule and process for generating acquisition data. NCC operators determine the schedule and process for generating TDRS acquisition data. Acquisition data are transmitted to the NCCDS according to schedules agreed to with each customer. Typically, MOCs supporting orbiting spacecraft transmit updated acquisition data to the NCCDS daily. STS, and possibly other missions, update on-orbit acquisition data as needed.

Maneuver data, including launch, reentry, and on-orbit maneuvers, are transmitted to the NCCDS minutes, hours or days prior to initiating the maneuver. The data may be replaced with updated data several times including in near-real time during the maneuver. Permanent Earth station vectors are occasionally transmitted to the NCCDS if the MOC updates the survey or the NCC operator requests a retransmission. Permanent Earth station vectors can also be provided to the NCC in hard-copy form and entered manually into the NCCDS. Test data of all types are transmitted to the NCCDS on schedules determined by the test director to meet the test objectives.

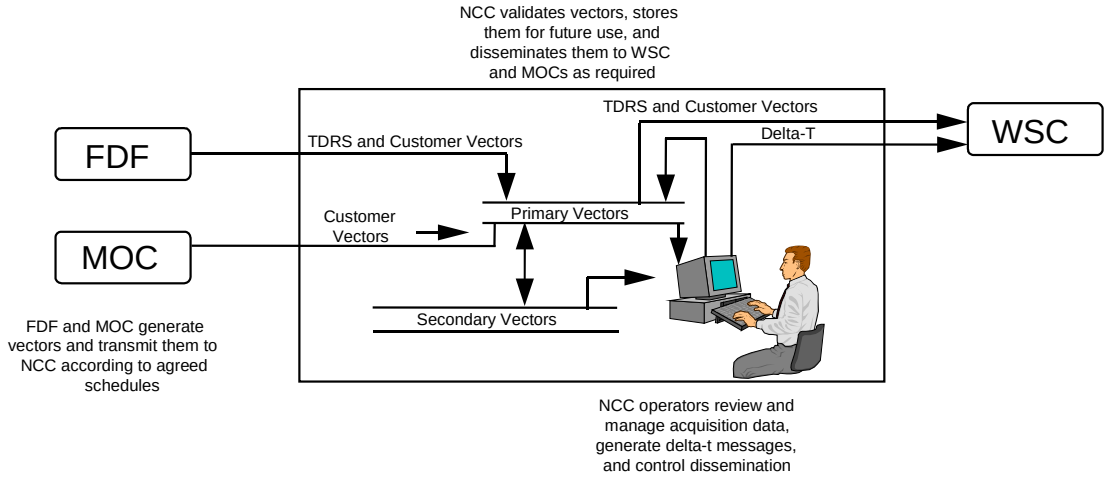


Figure 5–16. Acquisition data handling operations overview

The NCC receives acquisition data messages from the FDF or customers. Each vector is stored in an NCCDS database and evaluated to determine if it meets WSC vector validation criteria. The NCCDS evaluates all maneuver sequences to determine if they meet WSC maneuver sequence validation criteria. The NCCDS does not validate the accuracy of the vector components. The NCC operator and the source of the message are notified of vector and maneuver sequence

validation failures. The NCCDS does not permit invalid vectors or sequences to be used for mission support.

Acquisition data are transmitted by NCCDS to WSC on a scheduled or unscheduled basis as required to meet operational needs. The NCCDS provides several modes for operators to control transmission of vectors. In manual mode transmission, operators have the capability to select individual vectors or sets of vectors and initiate their transmission. If any vector of a maneuver sequence is selected for transmission, all vectors of the sequence are transmitted.

Other modes of transmission depend on the operator specifying a set of transmission rules to identify the vectors to be transmitted. The rules specify the SICs, vector types, destinations, frequency, and timespan. Operators can create, modify, or delete multiple rule sets, or activate or suspend individual rules.

For semiautomatic mode transmission, operators select and activate a rule or rules for automatic transmission at the specified intervals. At the specified times, the system notifies the operator of the impending transmission. If the operator does not require a review of the vectors, they are automatically transmitted. The operator has the option to review the vectors selected for transmission, remove any from the list, or add additional vectors to the list. New vectors, received by the system after automatic transmission, are automatically evaluated to determine if they should be immediately transmitted because they meet the criteria of a previously executed transmission.

For normal or real-time throughput mode transmission, newly arriving vectors that would have been selected by an active rule are automatically transmitted. For normal transmissions, operators have the option to review the vectors.

In response to launch slips, vector epochs are adjusted at the WSC by transmitting a delta-T message (time interval by which each component of a given set of acquisition data is to be moved in time). The launch facility verbally notifies the NCC of a launch slip. The NCC operator generates a delta-T message and transmits it to WSC. NCC operators can also adjust epochs of vectors stored in the NCCDS. The operator notifies FDF verbally of the launch slip.

Abbreviations and Acronyms

AIS	Automated Information Systems
BRTS	Bilateration Ranging Transponder System
CCTV	closed-circuit television
COTS	commercial off-the-shelf
DBA	database administrator
DBMS	database management system
EOS	Earth Observing System
ESA	European Space Agency
FDF	Flight Dynamics Facility
GHB	GSFC handbook
GN	Ground Network
GNSS	Ground Network Scheduling System
GRO	Gamma Ray Observatory
GSFC	Goddard Space Flight Center
GUI	graphical user interface
HDRM	high data rate multiplexer
HGA	high-gain antenna
HST	Hubble Space Telescope
ICD	interface control document
IIRV	improved interrange vector
IONET	IP operational network (NISN)
ISS	International Space Station
JSC	Johnson Space Center
LAN	local area network
LCP	left-hand circular polarization
LGA	low-gain antenna
MAF	multiple-access forward

MAR	multiple-access return
MDM	multiplexer/demultiplexer
MMDPS	Multimission Display Processing System
MO&DSD	Mission Operations and Data Systems Directorate
MOC	mission operations center
MOSA	mission operations support area
MSFC	Marshall Space Flight Center
MTBF	mean time between failures
MTTR	mean time to repair
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications
NASDA	National Space Development Agency
NCC	Network Control Center
NCCDS	Network Control Center Data System
NCCPO	NCC Project Office
NISN	NASA Integrated Services Network
NHB	NASA handbook
NMI	NASA Management Instruction
NTDS	NCC Timing Display System
NTS	NCC Test System
OCD	operations concept document
OPM	Office of Personnel Management
PMP	Project Management Plan
PN	pseudorandom noise
POCC	Payload Operations Control Center
POSIX	Portable Operating System Interface for Computer Environments (IEEE 1003.1, FIPS 151, ISO/IEC 9945-1)
RCP	right-hand circular polarization
RF	radio frequency
RFI	radio frequency interference

SA	single access
SAR	schedule add request
SAS	Service Accounting Segment
SC3	sensitivity/criticality level 3 (AIS)
SDE	Software Development Environment
SDPF	Sensor Data Processing Facility
SMAF	S-band multiple-access forward
SMAR	S-band multiple-access return
SGLT	Space-Ground Link Terminal
SIC	support identification code
SLR	service level report
SM	statistical multiplexer
SN	Space Network
SOC	Simulation Operations Center
SRD	system requirements document
SRM	schedule result message
SSAF	S-band single access forward
SSC	service specification code
STDN	Spaceflight Tracking and Data Network
STGT	Second TDRSS Ground Terminal
STS	Space Transportation System
SUPIDEN	support identifier
T&DA	tracking and data acquisition
T&T	Test and Training
TBD	to be determined
TBR	to be reviewed
TBS	to be supplied
TCP/IP	Transmission Control Protocol/Internet Protocol
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System

TSW	TDRS scheduling window
TT&C	tracking, telemetry, and command
UDP	User Datagram Protocol
UPS	User Planning System
USM	user schedule message
UTC	coordinated universal time
VDS	Voice Distribution System
VIC	vehicle identification code
WSC	White Sands Complex
WSGT	White Sands Ground Terminal

Glossary

acknowledgment	Confirmation of receipt of messages, according to communications protocol.
acquisition data	Spacecraft orbit data used to determine antenna pointing and Doppler compensation (IIRVs).
acquisition data handling	NCCDS function for receiving, storing, and transmitting acquisition data.
active period	The period of time covered by published schedules.
active schedule	The collection of all events for which customer schedules have been disseminated.
add request	A specific schedule request to add a single event to the schedule.
alternative schedule	One of several batch schedules generated using selected sets of requests or scheduling priorities.
alternate add request	*See* primary and alternate requests
approved service requirements	Prenegotiated levels of SN service support to be provided to a customer.
automatic schedule update phase	The time period during which incoming schedule add requests will be automatically processed.
batch schedule phase	The time period during which incoming schedule add requests will be batched under operator control.
capability to edit all schedule requests	Operator modification of forecast and active period requests to reduce the need for customer resubmission of revised requests and to permit rescheduling of impacted events.
conflict	A situation that occurs when a request for network resources cannot be granted, because the resources are assigned to another request.
conflict identification	NCCDS capability to detect and display nonschedulable requests with full particulars on items in conflict and potential changes needed for success.

conflict resolution	The process which attempts to schedule requested events when more than one event requests or is allocated the same resource.
conflict-resolution strategies	Operator actions to resolve conflicts between requests and existing scheduled events (e.g., changing start times or durations of either the request or the existing event).
conflict-resolution tools	Interactive operator tools provided as NCCDS scheduling enhancements. They assist the operator in resolving conflicts by providing information on conflicting resources and scheduled events and providing a selection of strategies to use in resolving the conflicts.
current schedule	*See* active schedule
customer	*See* SN customer
customer event	A combination of services (forward and return links, tracking, and end-to-end test) in a particular time sequence and with specific durations allocated to a particular customer spacecraft using a single TDRS for a continuous period of support.
customer flexibility	Customer ability to allow the NCCDS to select some or all of the start times, durations, TDRS, antenna and other SN resources, to increase the SN scheduling success.
customer service request	Customer-provided request for SN services as defined by a Schedule Add Request (SAR) electronic message (specific schedule request).
customer spacecraft characteristics	Data parameters (e.g., spacecraft and customer identification codes, passwords, customer destination and interface codes) maintained for each customer spacecraft by NCCDS for use in constructing scheduling messages and acquisition data processing.
customer vector	IIRV for customer spacecraft used by ground terminal to determine TDRS antenna pointing and Doppler compensation.
customer-assigned priorities	Customer assessments of the criticality of individual schedule requests used to assure that more important requests have increased scheduling success.
customer-specified freeze time	A customer specified point at which NCCDS freezes requested start times and durations. *See* freeze time

data administration	NCCDS function for creating, controlling, and maintaining resource and customer data needed for scheduling SN resources and for acquisition data handling.
database	The data stored by the NCCDS.
data stream	An independent data signal contained within a service. For example, I and Q channels are separate data streams within a service.
declined request	A schedule request that has been processed without placing an event on the schedule.
delete request	A specific schedule request to delete a scheduled event.
delta-T	The time interval by which each component of a given set of acquisition data is to be shifted in time.
Doppler shift prediction and compensation	Process that computes frequency shifts and adjusts spacecraft transceivers accordingly.
end-to-end test	A TDRSS service used to simulate customer satellite K- and S-band communications.
evaluation of alternative schedules	Comparison by the operator of several initial alternative schedules using different evaluation criteria.
event	*See* customer event
event start tolerances	The plus and minus values specifying the time that an event can be shifted forward or backward to resolve a conflict.
event termination	The end of an event, either at its normally scheduled termination time, or when requested by the customer or an NCC operator.
flexible service durations	Customer-specified duration ranges (i.e., minimum acceptable and nominal durations) for each service within a schedule request.
forecast period	The period of time in advance of publication (transmission) of the weekly schedule, during which schedule requests are received and the schedule developed.
freeze time	The point at which NCCDS freezes requested start times and durations; prior to this point NCCDS retains their flexibility in shifting start times and duration for added scheduling success and reduced conflicts.

graphical user interface	Operator interface using graphical elements (e.g., windows, menus, buttons) to provide a consistent interactive interface to NCCDS functions.
improved interrange vector (IIRV)	State vector that contains accurate values for the position and velocity of an orbiting spacecraft at a specific epoch (time) for use in predicting its future orbit.
initial alternative schedule	One of several potential forecast schedules generated based on a particular choice of scheduling objectives.
interface channel	A NISN communication data channel connecting SN elements and customer facilities.
interference	A degradation in communication due to noise.
message format	Specification of a message whose text is fully defined in advance by a known set of values to express the contents of any field in the message.
multiple access	The S-band communications capability in TDRSS which provides one forward and five simultaneous return links per TDRS using phased array techniques.
NCC scheduling goals	The provision of at least 90 percent of approved requirements to each customer, achieved with improved system operability and maintainability.
open resource selection or resource flexibility	Customer permission for the NCC to automatically select a TDRS and/or TDRS antenna to achieve increased overall scheduling success.
operator evaluation of alternative schedules	Use of graphical NCCDS operator interfaces to permit operator comparison of various alternative schedules and identification of problems within individual schedules.
optimization to meet SN goals	NCCDS scheduling enhancement to provide operator-selected scheduling strategies to optimize the schedule with respect to the selected criteria.
overlapping support	A period of simultaneous support for one spacecraft to effect a change of TDRSs or antennas on a TDRS.
partial TDRS equipment failure	Loss of one or more resources or capabilities on one or more TDRSs, thereby limiting available SN resources.
premium event	An event scheduled in response to a request received less than 45 minutes prior to the requested event start time and billed at a premium rate.

primary and alternate requests	A set of customer-specified alternatives that allows a second or third choice request to be scheduled if the first choice cannot be accommodated.
priority, customer-assigned	The relative level of importance of each schedule add request, as specified by the customer (e.g., emergency, critical, normal, or supplemental).
priority, mission	An absolute ranking of all SN customers, as specified by NASA management.
privileges	Specifications of which NCCDS capabilities are accessible to each NCC operator, subject to modification as operational conditions warrant.
prototype event	A combination of service specification codes, service durations, and relative start times defined in advance for a customer spacecraft for use in the scheduling process.
radio frequency interference	Signal degradation that occurs when two or more simultaneously transmitting radiation of identical polarity with overlapping bandwidths are received by a supporting antenna.
real-time transmission	Throughput by the NCCDS of a vector sequence to the ground terminal under expedited conditions (i.e., suppression of acknowledgment protocol to shorten the time needed to complete the sequence's transmission).
replace request	A customer request to delete a scheduled event and replace it with another. If the NCCDS is unable to effect the replacement, the original event remains on the schedule.
resource flexibility	The NCCDS capability to select from one or more customer-specified TDRSs or antennas on those TDRSs, as available.
retransmission of schedule messages	The NCCDS capability to retransmit at customer request any type of schedule message; applicable in particular to schedule delete messages.
schedule	A complete set of conflict-free customer events that fully specifies the allocation of SN resources.
schedule dissemination	The process by which the NCCDS transmits schedules to customers and SN elements, including customer facilities, TDRSS ground terminals, FDF, and SDPF.

schedule generation and maintenance	The NCCDS function for processing schedule requests, generating alternative schedules, maintaining the schedule, resolving conflicting requests, and responding to operational changes.
schedule generation period	The period of time in advance of publication (transmission) of the weekly schedule, during which the schedule is developed.
schedule generation process	The process which produces customer events through the use of prototype events, service specification codes, and specific requests.
schedule request	*See* specific schedule request
schedule request flexibility	Non-rigid specification of request parameters and SN services, which results in increased overall scheduling success.
scheduling algorithm	A method used by NCCDS for generating a forecast schedule.
scheduling criteria: satisfaction of commitment to customer	An indication of the degree to which an alternative schedule satisfies a customer's overall pre-negotiated requirements for SN support.
scheduling order data message (SHO)	A message sent to WSGT and STGT which defines the scheduled services and parameter values for a particular event.
secure environment	A physically defined space containing sensitive information subject to physical protection and personnel access controls.
service	Functional support for a customer provided by the SN for a continuous period of time. Services include forward links, return links, tracking, and end-to-end test.
service-level report (SLR)	A message from TDRSS concerning the operational capabilities of a particular resource. It will indicate if a resource is operable (green) or not operable (red).
service specification code (SSC)	A code that specifies the configuration of a single service for a given customer.
service time flexibility	Tolerance on service start times to allow the service to be moved relative to the event start time if necessary to improve scheduling success.

setup time	While preparing to support an event, that time required to properly configure equipment.
single access (SA)	A service which is able to support only one event at a time; also refers to one of the steerable antennas on a TDRS.
SN customer	Any entity that makes use of STDN for operations, simulations, or testing.
SN elements	TDRSS ground terminals, NCC, SOC, FDF
SN resources	Resources used to support customer testing and communication with their spacecraft, such as the TDRSs, the ground terminals (STGT and WSGT) and the resources within those terminals, and the Nascom communications circuits.
specific schedule request	A request to change a customer schedule (e.g., add, delete or replace an event).
start time tolerances	*See* event start tolerances
SUPIDEN	A seven character code used to identify the satellite or task being supported. It is broken into three parts: class, SIC, and function. Class identifies the major entity for which the support is being provided (e.g., Houston, network, GSFC). The SIC identifies the mission being requested. The function is an identification of the type of support being provided (e.g., launch simulation). SUPIDEN codes and their meanings are explained in 534-808.
support for launch slips	Use of NCCDS operator interfaces and scheduling strategies to facilitate the identification and rescheduling of customer events impacted by a launch slip.
support for unanticipated resource changes	Use of NCCDS operator interfaces and scheduling strategies to identify events impacted by losses in SN resources and to reschedule them effectively.
switchover	The transition of operations from the prime to the backup system, or vice versa.
target of opportunity	A situation that arises unpredictably (e.g., a scientific event such as an erupting volcano or a comet collision) and requires extra customer service on a priority basis.

TDRS scheduling window (TSW)	A specification for a TDRS (generated by the customer or the customer designated facility) of a time period when the customer's spacecraft may be supported by that TDRS. The TSW may be based on antenna view constraints, attitude and blockage effects, and any other mission timeline constraints that apply.
TDRS vector	IIRV for a TDRS used by the customer to determine customer spacecraft antenna pointing and Doppler compensation.
Tracking and Data Relay Satellite (TDRS)	A communications relay satellite used as the link between the TDRSS ground terminal and a customer spacecraft.
Tracking and Data Relay Satellite System (TDRSS)	A set of space and ground resources consisting of several geosynchronous TDRSs, the WSGT and the STGT, and in-orbit spare satellites. TDRSS relays telecommunication signals between low-altitude, Earth-orbiting spacecraft and customer control and data processing facilities. It also relays telecommunications signals between near Earth or Earth-sited systems (e.g., launch and landing) and their operators.
vector transmission	Dissemination of customer and TDRS vectors to the ground terminals; also, transmission of TDRS vectors to customers.
wait list	A list of declined requests that are reprocessed when resources are relinquished by events being deleted from the active schedule.
wait-list request	A request to place a declined request on the wait list.
weekly schedule	The schedule that contains the events scheduled by the schedule generation run.